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THIS VOLUME IS DEDICATED TO

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by sheet with devotion, dedication and single-mindedness of purpose from its
small beginnings to its present considerable state; and also, who has contributed
many original papers on the South African Amaryllidaceae and Liliaceae to
the pages of this journal.

TWO NEW SPECIES OF *ASPLENIUM* FROM SOUTHERN AFRICA

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Abstract

Cytotaxonomic observations are recorded on *A. ramlowii* Hier., *A. blastophorum* Hier. and material related to each of these species which is described as *A. schelpei* and *A. parablastophorum* respectively.

Uittreksel

TWEE NUWE SOORTE *ASPLENIUM* VAN SUIDELIKE AFRIKA

Sitotaksonomiese waarnemings word aangeteken oor *A. ramlowii* Hier., *A. blastophorum* Hier. en materiaal wat betrekking het tot hierdie twee soorte, wat beskryf word as *A. Schelpei* en *A. parablastophorum* onderskeidelik.

Cytotaxonomic studies on *Asplenium ramlowii* Hier., *Asplenium blastophorum* Hier. and material related to each of these species from southern Africa have suggested the presence of two additional taxa.

Typical *A. ramlowii* is a tetraploid species having 72 bivalents at meiosis whilst some morphologically allied material from Southern Rhodesia and the Transvaal, South Africa is octoploid with twice this number of chromosomes. The octoploid specimens represent a hitherto undescribed species for which the name *A. schelpei* is proposed. The second new species is based on some tetraploid material from the Melsetter District, Southern Rhodesia which resembles the octoploid *A. blastophorum*. It is nevertheless readily distinguished from the latter species and is described here as *A. parablastophorum*.

The chromosome number, locality and spore size of the living representatives of each of the four species which have been available for cytological examination may be found in the appendix.

A. ramlowii Hier. Eng. Jahrb., 46, 372, 1911.

This is rather a distinctive tetraploid species with a creeping rhizome, clothed in light brown papery rhizome scales up to 10 mm long, and bearing short stiff linear-lanceolate fronds. The lamina is broadest about the middle and the lower pairs of pinnae are gradually reduced towards the base (fig. 1a). The pinnae vary from an almost entire condition in small specimens to a deeply pinnatifid condition in larger more luxuriant specimens.

Ecologically it favours rather open habitats often growing on rocks, in rock crevices or in grassland among boulders.

It is found in the Matobo, Melsetter, Umtali, Makoni and Salisbury Districts of Southern Rhodesia, Mozambique and Tanzania.

A. schelpei A. Braithwaite species nova.

Rhizoma breve repens, paleis ferrugineis clathratis concoloribus linearibus usque ad 7 mm longis, marginibus paucis projecturis filiformibus munitis. *Frondes* caespitosae rigidae coriaceae. *Stipites* (5—) 8—15 (—24) cm longi sqamosi atrobrunnei sed aliquando viridescentes in superficiebus versus laminam. *Lamina* (7—) 9—20 (—30) cm longa, 4—9 cm lata, oblong-lanceolata, imis quintis paribus pinnarum inter se aequalibus vel vix reductis versus basale par, bipinnata; rhachidis sparsim squamata, pars infima per 1/2 vel 2/3 longitudinis in pagina abaxiale atrobrunnea, cetero viridis. *Pinnae* 7—15 jugatae usque ad 5 cm longae, 2,5 cm latae, elongato-trapeziformes, in superficiebus glabrae nitidae florido-virides in paginis inferis sparsim fibrillosae impolitae pallidiores virides, 1—5 pinnulis infra apicem lobatum. *Pinnulae* rotundato-cuneatae vel rotundato-obtrullatae, apicibus irregulariter dentatae non profunde et saepe vadose lobatae. *Sori* indusiati, 5—12 mm longi, inferne paginam pinnulae vel loborum pinnae fere omnino obtegentes. *Sporae* monoletae 38—50μ longae (ordo mediis 42—47μ); perispora cristis tenuibus anastomosantibus usque ad 12μ latis. Chromosomatum numerus n = 144; reproductio sexualis.

Type: South Africa, Transvaal, Pilgrims Rest Division, New Chum Falls nr. Pilgrims Rest. In rock crevices above the Falls. 27/12/60. *Braithwaite* 140. (BM holotype; BOL Herb. Braithwaite, isotypes).

Rhizome short creeping, clothed in reddish brown clathrate concolorous linear scales up to 7 mm long, bearing a few filiform projections at the margins. *Fronds* tufted stiff and coriaceous. *Stipes* (5—) 8—15 (—24) cm long, scaly, dark brown but becoming green on the upper surface towards the lamina. *Lamina* (7—) 9—20 (—30) cm long, 4—9 cm wide, oblong-lanceolate, the lowermost five pairs of pinnae equal in length or only slightly reduced towards the basal pair, bipinnate; rachis sparsely scaly and dark brown on the lower 1/2 or 2/3 of the abaxial surface, green elsewhere. *Pinnae* 7—15 pairs, up to 5 cm long, 2,5 cm wide, elongate-trapeziform, glabrous and shiny bright green on the upper surface and sparsely fibrillose and matt paler green on the under surface, with 1—5 pinnules below a lobed apex. *Pinnules* rounded cuneate or rounded obtrullate with irregularly shallowly dentate apices which are often slightly lobed. *Sori* indusiate, 5—12 mm long, covering almost completely the undersurface of the pinnules and pinnae lobes. *Spores* monolete, 38—50μ long (range of means 42—47μ); perispore with thin anastomising wing up to 12μ wide. Chromosome number n = 144; reproduction sexual.

The following herbarium specimens may be attributed to *A. schelpei:*

SOUTH AFRICA

Transvaal

Pilgrims Rest Division: Top of falls by town of Sabie, *Wager* 34 (PRE); Kruger National Park, Numbi-Nek, on S. side of ridge in rock clefts, c. 2 000′, *Schjiff* 31 (PRE); Kruger National Park, Pretoriuskop area, Numbi. Indonga or damp places, 2 000′, *Schjiff* 3456 (PRE); Kruger National Park, Thlalbye. Damp places in kloof, *Schjiff* 4207 (PRE); Bourkes Luck Potholes nr. Pilgrims Rest. In deep rock crevices along top of ravine. *Braithwaite* 220 (BM, BOL).

Zoutpansberg Division: Sibasa, wet rocks, 2 500′, *Junod* 4598 (PRE) Sibasa, *Junod* s.n. (PRE).

SOUTHERN RHODESIA

Umtali District: At base of precipice M'pembi. In grass on solid granite wall *Chase* 3446 (SRGH); Eastlands. On rock face in gorge near P.E.A. border. 3 200′ *Chase* 3939 (BOL, SRGH); Zimunya's Reserve *Chase* 3948 (SRGH); Murakwa's Hill Commonage. 3 900′ mixed coll. with *A. ramlowii Chase* 4394 (SRGH); Murakwa's Hill, Site I. In light shade among small boulders. 4300′ *Chase* 5688 (BOL, PRE, SRGH); Murakwa's Hill, Site II. Hilltop in crevices of boulders away from sun. 4 300′ *Chase* 5689 (BOL, PRE, SRGH); Zimunya's Reserve. In shade in crevices among boulders, S. slopes of Mt. 3 200′ mixed coll. with *A. ramlowii, Chase* 6074 (SRGH); Mt. Currie Farm. In crevices of boulders and rocks on mt. S.W. of Jenya Mt. 3 400′ mixed coll. with *V. ramlowii, Chase* 6579 (SRGH); Marakwa's Hill, Site III. *Williams* s.n. (UMT 7) (BM, BOL); Murakwa's Hill, Site Williams s.n. (UMT 12) (BM, BOL).

This new species resembles *A. ramlowii* but is distinguished by its shorter, darker and narrower rhizome scales, longer and broader fronds with the lowermost pairs of pinnae of a similar width or only slightly reduced towards the basal pair and by its larger, more dissected pinnae with distinct rounded pinnules. (fig. 1).

The two species are also closely allied ecologically and where their distributions overlap in the Umtali District of Southern Rhodesia they may be found in close proximity, particularly in areas such as Murakwa's Hill and Zimunya's Reserve. There is no direct evidence available at present for natural hybrids between the two species but in view of their close proximity, the discovery of interspecific hexaploid hybrids might perhaps be expected in these localities.

A. schelpei also shows some less obvious but nevertheless significant morphological affinities with *A. splendens*, which is a tetraploid species confined to South Africa. It shares with this species longer and broader fronds than those found in *A. ramlowii* and also larger, more dissected pinnae with rounded pinnules.

The precise relationships of *A. schelpei* with *A. ramlowii* and *A. splendens* have yet to be determined but on morphological evidence alone there are grounds for suggesting that both the tetraploids have been involved in the origin of the octoploid.

The distribution of *A. schelpei* extends from the south-eastern Transvaal, South Africa northwards to the Umtali District, Southern Rhodesia while *A. ramlowii* is found in Tanzania, Mozambique and in Southern Rhodesia as far

Fig. 1.

Silhouettes of *Asplenium* fronds. All one quarter natural size. a) & b) *A. ramlowii* Williams s.n. (HL 8), Kwakasipu, nr. Umtali, Southern Rhodesia. a) from a cultivated plant. b) from a wild collection. c), d) & e) *A. schelpei* All fronds from wild material. c) Braithwaite 140 New Chum Falls, nr. Pilgrims Rest, Transvaal, South Africa. d) Williams s.n. (UMT 7) Murakwas Hill, Umtali, Southern Rhodesia. e) Braithwaite 220 Bourkes Luck Potholes, nr. Pilgrims Rest, Transvaal, South Africa.

south as the Matopo and Melsetter Districts and *A. splendens* is confmed to South Africa extending from eastern Cape Province to the Zoutpansberg in the northern Transvaal. *A. schelpei*, therefore, bridges the gap between the ranges of the two tetraploids. The distribution pattern of the three species perhaps lends further support to the suggestion that the parentage of *A. schelpei* involves *A. ramlowii* and *A. splendens*.

A cytogenetic investigation which includes all three species is currently being undertaken to determine their precise inter-relationships and in particular to determine the mode of origin of *A. schelpei*.

A. blastophorum Hier., Eng. Jahrb., 46, 378, 1911.

The two representatives of this widely distributed African species which have been cytologically examined are both octoploid (see appendix) and possess con-

spicuously gemmiferous fronds (fig. 2a). The buds normally appear in mature fronds near the apex but in larger specimens they may also arise along the rachis or even on the upper surface of the lower pinnae. A careful search of herbarium material over the entire range of the species indicates that it is consistently gemmiferous.

A. parablastophorum Braithwaite species nova.

Rhizoma repens, paleis usque ad 5 mm longis, $\frac{3}{4}$ mm latis, lineari-subulatis clathratis atrobrunneis, cellulis in parte mediana vinosis crassis parietibus, tenuescens et lutescens versus marginem, marginibus paucis filiformibus munitis. *Frondes* usque ad 60 cm longae coriaceae non-gemmiferae. *Stipites* 30—35 cm longi. *Lamina* 22—30 cm longa, 13—19 cm lata, conspicue triangularis, tripinnata, 9—11 paribus pinnarum suboppositis. *Pinnae* c. 10 cm longae 5 cm latae, elongato-trapeziformes, patulae, usque ad 10 pinnulis infra apicem lobatum. *Pinnulae* minores cuneate-spathulatae, apicibus rotundatis et dentatis; pinnulae majores elongatae 1—3 segmentis infra apicem lobatum; segmentia pinnulis minoribus similia. *Sporae* monoletae, 28—37μ longae (ordo mediis 32—33μ); perispora cristis tenuibus anastomosantibus usque ad 9μ latis. Chromosomatum numerus n = 72; reproductio sexualis.

Type: Southern Rhodesia, Melsetter District, Chimanimani Mts. Forest on Timbiri river $\pm$1 mile up from Haroni. Frequent on ft. floor or occasionally as low level epiphyte. 2 000′ 13/2/58 Mitchell 381 (BOL, holotype; SRGH, isotype)
Southern Rhodesia, Melsetter District, Lusitu River, Lusitu Nature Reserve. May 1959 *Ball* 1 (SRGH, paratype)

Rhizome creeping, covered in dark brown clathrate linear-subulate scales up to 5 mm long and $\frac{3}{4}$ mm broad, with cells in the central part with thick deep red walls becoming thinner and yellow towards the margin, and bearing a few filiform projections at the margins. *Fronds* up to 60 cm long coriaceous and non-gemmiferous. *Stipes* 30—35 cm long. *Lamina* 22—30 cm long, 13—19 cm wide, conspicuously triangular, tripinnate, with 9—11 subopposite pairs of pinnae. *Pinnae* c. 10 cm long 5 cm broad, elongate-trapeziforme, spreading with up to 10 pinnules below a lobed apex. Smaller *pinnules* cuneate spathulate with rounded dentate apices; larger pinnules elongate with 1—3 segments below a lobed apex; segments similar to the smaller pinnules. *Spores* monolete, 28—37μ long (range of means 32—33μ); perispore with a thin anastomising wing up to 9μ wide. Chromosome number n = 72; reproduction sexual.

The single cytological record for this species (see appendix) is based on a chromosome count from one of two plants raised from spores taken from the specimen collected by Ball in the Government Herbarium at Salisbury. Unfor-

tunately both of these plants have been lost before adequate herbarium specimens could be preserved. The illustration in fig. 2b is based on a tracing from the specimen designated as the holotype in the Bolus Herbarium at the University of Cape Town.

This new tetraploid species resembles *A. blastophorum* but is readily distinguished by its non-gemmiferous and broader triangular fronds bearing much more finely dissected pinnae with cuneate- spathulate pinnules and pinnule lobes. (fig. 2)

It is at present known only from the Melsetter District of Southern Rhodesia.

FIG. 2.

Silhouettes of *Asplenium* fronds. All one quarter natural size. a) *A. blastophorum* Braithwaite 48 Ngoya Forest, Port Durnford, Natal, South Africa. b) *A. parablastophorum* Mitchell 131 Chimanimani Mts., Melsetter District, Southern Rhodesia.

Details of the material which has been cytologically examined.

Species Locality	Collector & Number	Cytology	Spore size*
A. ramlowii Hier.			
Kwakasipu, nr. Umtali, Southern Rhodesia.	Williams s.n. (HL 8)	n=72	37,3±3,89
A. schelpei A. Braith. sp. nov.			
New Chum Falls, Pilgrims Rest, Transvaal, S. Africa.	Braithwaite 140	n=144	43,8±3,90
Bourkes Luck Potholes, nr. Pilgrims Rest, Transvaal, South Africa.	Braithwaite 220	n=c.144	45,3±3,88
Murakwas Hill, Umtali, Southern Rhodesia.	Williams s.n. (UMT 7)	n=144	47,5±3,90
Murakwas Hill, Umtali, Southern Rhodesia.	Williams s.n. (UMT 12)	n=144	46,3±3,91
A. parablastophorum A. Braith. sp. nov.			
Lusitu R., Lusitu Nature Reserve, Melsetter Distr., Southern Rhodesia	Ball 1.	n=72	32,2±1,85
A. blastophorum Hier.			
Ngoya Ft., Port Durnford, Mtunzi Div., Natal, South Africa.	Braithwaite 48	n=144	39,4±3,92
Bandula Ft., Manica Distr., Mozambique.	Chase 6839	n=144	40,5±2,05

* Means for 100 spores.

Herbarium material of all the plants listed, with the exception of *A. parablastophorum* (see text), will be deposited at the British Museum (Natural History), London and the Bolus Herbarium, Cape Town.

THE CYTOTAXONOMY OF THE *ASPLENIUM SPLENDENS* COMPLEX IN SOUTH AFRICA

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Abstract

Morphological, ecological and cytological studies of *A. splendens* Kze. and related material in South Africa have shown it to be a polyploid species complex. *A. splendens* subsp. *splendens* is a tetraploid (n=72) while some closely related octoploid (n=144) material is referred to *A. multiforme* Kr., a species which has not been recognised in recent works on the fern flora of South Africa. A second tetraploid from the Drakensberg Mountains, which has previously been confused with *A. aethiopicum* (Burm) Bech. s.l., is also placed in the complex as a result of hybridisation experiments involving *A. splendens* subsp. *splendens* and *A. aethiopicum*. It may be regarded as a member of the same ecospecies as *A. splendens* and has been described for the first time as *A. splendens* subsp. *drakensbergense*. Analysis of the meiotic pairing in hybrids synthesised between the three members of the complex suggest that *A. multiforme* is an intervarietal autopolyploid which has arisen by hybridisation between the two subspecies of *A. splendens* followed by doubling of the chromosome number.

Uittreksel

DIE SITOTAKSONOMIE VAN DIE *ASPLENIUM SPLENDENS* KOMPLEKS IN SUID-AFRIKA.

Morfologiese, ekologiese en sitologiese studies van *Asplenium splendens* Kze. en verwante materiaal in Suid-Afrika het getoon dat dit 'n poliploïede spesies kompleks is. *A. splendens* subsp. *splendens* is 'n tetraploïed (n=72) terwyl sommige naby verwante oktoploïede (n=144) materiaal as *A. multiforme* Kr. bekend staan ('n spesies wat nie in die nuutste werke oor die varing flora van Suid-Afrika erken word nie). 'n Tweede tetraploïede vanaf die Drakensberge wat voorheen met die *A. aethiopicum* (Burm) Bech. s.l., verwar was, is ook as 'n resultaat van kruisings eksperimente met *A. splendens* subsp. *splendens* en *A. aethiopicum* in die kompleks geplaas. Dit mag beskou word as 'n lid van dieselfde ektospesies as *A. splendens* en was al vir die eerste keer beskryf as *A. splendens* subsp. *drakensbergense*. 'n Oorsig van die meiotiese paring in basters saamgestel uit die drie lede van die kompleks stel voor dat *A. multiforme* 'n tussen variëteits outopoliploïed is wat uit verbastering tussen die twee subspesies van *A. splendens* ontstaan het gevolg deur verdubbeling van die kromosoomgetalle.

Introduction

Asplenium splendens Kze. was originally described in 1836 from some South African specimens collected by Ecklon from the Kat River and by Drège from the lower reaches of the Umzimvubu River (Port St. Johns). A second closely related species, *A. multiforme* Kr., was subsequently described in 1900 from a Krook collection from Newmarket. Sim (1915) in the "Ferns of South Africa" did not recognise either of these taxa and erroneously placed them both under *A. cuneatum* Lam. Later Alston and Schelpe (1952) and Schelpe (1969) segregated the South African material under *A. splendens* but they did not distinguish *A. multiforme*.

Recent cytological studies have revealed two different chromosome numbers within *A. splendens* and have confirmed the presence of a species complex. Typical *A. splendens* is a tetraploid species with 72 chromosomes at meiosis whilst a plant from the eastern Cape has shown twice this number and is therefore octoploid. The octoploid material agrees in all respects with the specimen described as *A. multiforme* and, since it can be distinguished from the tetraploid material by careful morphological examination, its specific rank has been restored. Some further tetraploid material from the Drakensberg Mountains has also been included in the investigation because of its morphological similarity to *A. multiforme*. This material has in the past been loosely referred to *A. aethiopicum* (Burm.) Bech. s.l. and not recognised as part of the present complex, but during the course of the experimental studies it became evident that it is closely related to *A. splendens* and *A. multiforme*. It is, however, sufficiently different from typical *A. splendens* to merit taxonomic recognition and on the basis of the present experimental evidence it is recognised as a subspecies of *A. splendens* for which the name *drakensbergense* is proposed.

Experimental hybrids have been synthesised between the three representatives of the complex and meiosis studied in the hybrids in an attempt to analyse their inter-relationships. The hybridisation programme has also been extended to incorporate a representative of *A. aethiopicum* but this species is only included in the present communication to the extent required to interpret relationships within the *A. splendens* complex.

The observations recorded substantially clarify the taxonomic position of the material described as *A. splendens* subspecies *drakensbergense* and permit some conclusions to be reached on the relationships of the three members of the complex and, in particular, on the origin of the octoploid *A. multiforme*.

PLATE I.

1, 2 and 3 Permanent acetocarmine squash preparations of chromosome pairing at meiosis (X 1000).

1. Tetraploid hybrid between *A. splendens* subsp. *splendens* B 71, Pirie Forest and *A. splendens* subsp. *drakensbergense* Edwards s.n., Impendhle, showing regular chromosome pairing with 72 bivalents.

2. Tetraploid hybrid between *A. splendens* subsp. *splendens* B 71, Pirie Forest and *A. aethiopicum* McNeil s.n. Transvaal showing complete failure of chromosome pairing with 144 univalents.

3. Hexaploid hybrid between *A. multiforme* B 108, Askeaton and *A. splendens* subsp. *splendens* B 71, Pirie Forest showing 72 paired groups (trivalent and bivalent) and 51 univalents. For an explanatory diagram see fig. 5.

4, 5 and 6. Spores photographed in gum chloral (X 250).

4. *A. splendens* subsp. *splendens* B 259, Woodbush.

5. *A. splendens* subsp. *drakensbergense* Edwards s.n., Impendhle.

6. *A. multiforme* B 108, Askeaton.

The Material

The living plants which have been available during the investigation are listed in Appendix I with details of their locality, collector, chromosome number and spore size. All the plants have been successfully established in cultivation at the Botany Departments, first of the University of Leeds, and later, of the University of Nottingham. The material has been derived as living sporophytes either donated by correspondents in South Africa or collected by the author during fieldwork in South Africa between July 1960 and June 1961.

The following systematic treatment of the material is based on all the morphological, ecological and cytological observations and on the experimental results which are discussed in the following sections. It is placed here to provide a nomenclatural basis for the experimental work and also to orientate the reader so that he will be better able to evaluate the experimental data.

1a *A. splendens* Kze subsp. *splendens*

   A. splendens Kze Linn. 10, 516, 1836.

The material attributed to this subspecies possesses ovate-acuminate to sometimes nearly deltoid fronds up to 75 cm. long, which rise at intervals of $\frac{1}{2}$—1 cm. from a creeping rhizome covered with light brown clathrate scales. The fronds are bipinnate to tripinnate with 9—16 pairs of pinnae which are subdivided into as many as 14 cuneate rounded trapezioid pinnules. The larger pinnules are often divided again into cuneate rounded segments. The stipe is black or dark brown and the rachis is also dark on the undersurface for the greater part of its length.

All the living specimens which have been cytologically examined have proved to be tetraploid with 72 bivalents at meiosis (see Appendix I) and comparable pinnae from six of these plants are illustrated in fig. 1, a–f and rhizome scales from two representatives in fig. 2, a and b.

Although cytologically uniform, subspecies *splendens* shows considerable morphological variation particularly with regard to frond dissection and the shape of the pinnules. Fronds vary from a bipinnate condition with entire cuneate rounded pinnules to a fully tripinnate condition, where the lowermost pinnules are elongate and divided into several cuneate rounded segments. The latter form has been recognised as a variety by Kunze (1836) and Sim (1915). There is, however, a continuous gradation between the two extremes of frond dissection, sometimes on the same plant (see fig. 1, e and f), so that the separation of the more dissected usually larger form as a variety would be arbitrary and superfluous.
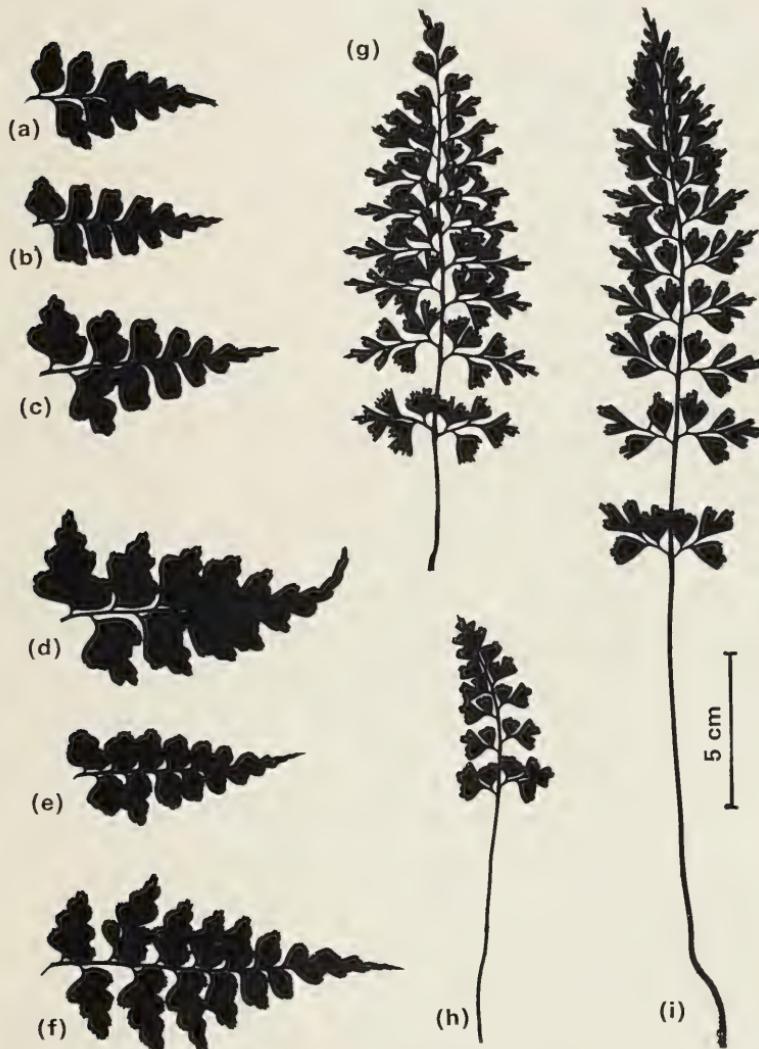
FIG. 1.

Silhouettes of pinnae and fronds of *A. splendens*. All half natural size. a), b), c), d), e), and f) subspecies *splendens*. Comparable pinnae from cultivated plants. a) B 41, Ngome Forest. b) B 59, Oribi Gorge. c) B 71, Pirie Forest. d) B 249 Magoebas Kloof. e) and f) B 259, Woodbush. g), h) and i) subspecies *drakensbergense* Edwards s.n. Impendhle. g) frond from cultivated plant h) and i) wild material. For full details of locality see Appendix I.

Much of the variation is a function of the age and condition of the plants as well as of ecological factors. Juvenile and small plants growing in open drier habitats generally possess entire cuneate pinnules with conspicuously rounded apices; while mature plants growing luxuriantly in moist shaded conditions are often tripinnate with markedly elongate and divided pinnules. Nevertheless even after several years in cultivation under similar conditions some variation persists in mature fronds as shown by the pinnae in fig. 1, a–f.

A. *splendens* subsp. *splendens* is primarily a forest taxon at altitudes ranging from 80—5 000 feet. It is usually seen in shade on the forest floor or on mossy boulders or more occasionally as a low level epiphyte, but it does extend beyond the present forest range particularly in the eastern Cape and Natal. In these areas it may be found in drier bush and wooded kloofs where it sometimes shows appreciable drought resistance. These 'outliers' away from the main forest areas may represent part of a relict flora from the time when the forested areas were more extensive than they are today. The distribution extends from the Albany Division in the Cape Province to the Zoutpansberg in the northern Transvaal (fig. 6).

1b. A. *splendens* subspecies drakensbergense, A. Braith. subsp. nov.

Rhizoma breve repens, paleis brunneis clathratis concoloribus lineari-subulatis, c. 5 mm longis, $\frac{1}{2}$ mm latis, margine projecturis interdum filiformibus munitis. *Stipites* 6—19 cm longi, laminis aliquando aequantes vel longiores, inferne atrobrunnei supra viridescentes, paleis eis rhizomatis similibus sed parvioribus sparse instructi. *Lamina* 5—16 cm longa, 2—5 cm lata, oblongo-lanceolata ad anguste ovata vel interdum anguste triangularis, bipinnata; rachide viride, paleis et fibrillis sparse instructa. *Pinnae* 6—13 -jugae suboppositae, usque ad 3 cm longae, 2 cm latae, trapeziformes, 1—4 pinnulis infra apicem lobatum. *Pinnulae* cuneatae apicibus truncatis irregulariter inciso-serratis, glabrae, imae saepe lobatae. Lobatae pinnarum et pinnularum oblongo-rectangulatae, apicibus truncatis. *Sori* usque ad 6 mm longi, versus basin pinnularum vel loborum pinnarum dispositi. *Sporae* brunneae, 33—48μ longae (ordo mediis 38—42μ); perispora spissate papillosa, cristis undulatis tenuibus 4—6μ latis anastomosantibus. Chromosomatum numerus n = 72; reproductio sexualis.

TYPE: Impendhle, Natal, South Africa. Nr. waterfall c. 5 000'. June 1961. *Edwards* s.n; living plant collected at the same time and cultivated at Nottingham. (BM, holotype; BOL, Herb. Braithwaite, isotypes).

Rhizome short creeping, covered with brown clathrate concolorous linear-subulate scales, c. 5 mm long, $\frac{1}{2}$ mm wide, bearing occasional filiform projections on the margin. *Stipes* 6—19 cm long, sometimes equalling or longer than the lamina, dark below becoming green above and bearing a few scales similar to,
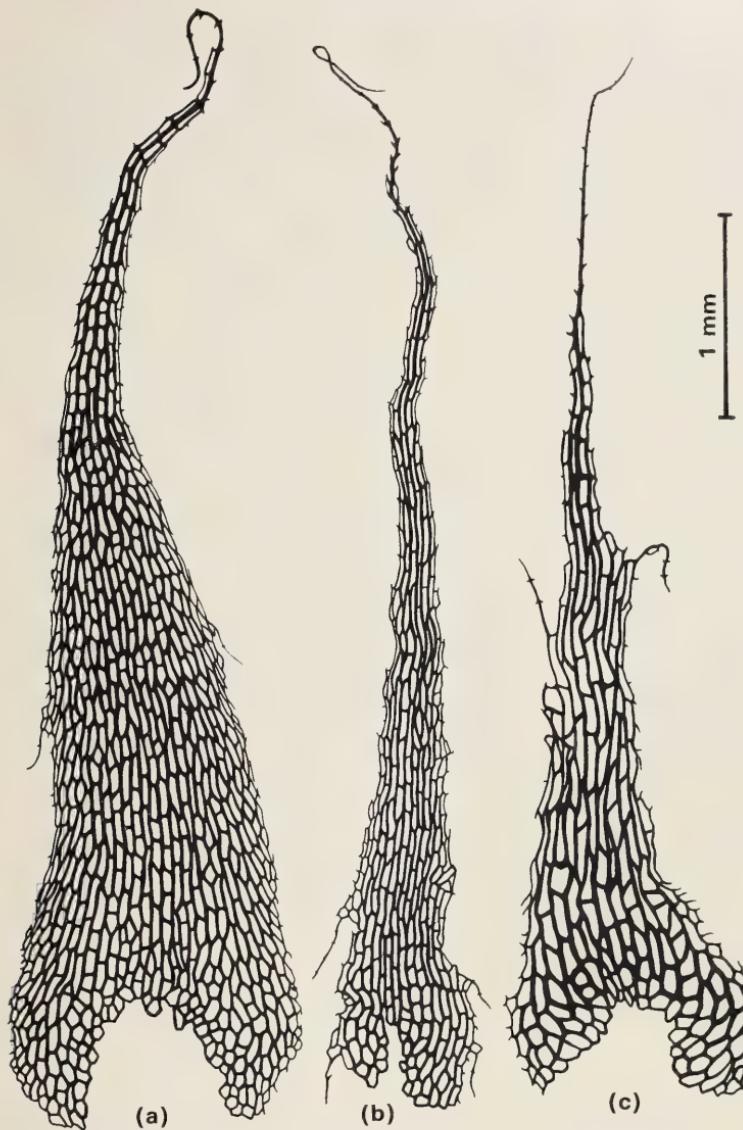
FIG. 2.
Rhizome scales of *A. splendens*.
a) subspecies *splendens* B 259, Woodbush. b) subspecies *splendens* B 71, Pirie Forest. c) sub-species *drakensbergense* Edwards s.n., Impendhle.

but smaller than, those of the rhizome. *Lamina* 5—16 cm long, 2—5 cm wide, oblong-lanceolate to narrowly ovate or occasionally narrowly triangular, bipinnate; rachis green, sparsely bearing a few scales and fibrils. *Pinnae* 6—13 subopposite pairs, up to 3 cm long, 2 cm wide, trapeziforme, with 1—4 pinnules below a lobed apex. *Pinnules* cuneate with truncate irregularly inciso-serrate apices, glabrous, the lowermost often lobed. Lobes of pinnae and pinnules oblong-rectangular with truncate apices. *Sori* up to 6 mm long and situated towards the base of pinnules and pinnae lobes. *Spores* brown, 33—48μ long (range of means 38—42μ); perispore densely papillose with a thin anastomising undulating wing 4—6μ wide. Chromosome number n = 72 (see Appendix I); reproduction sexual.

Silhouettes of three fronds from the type material are shown in fig. 1, g–i and a rhizome scale and the spores in fig. 2, c and Plate I, 5 respectively. A list of herbarium specimens attributed to subspecies *drakensbergense* may be found in Appendix II. It is characteristically a fern of rock crevices, rocky banks or screes at altitudes of 5 000 to 9 000 feet and at present is known only from Lesotho and the Natal Drakensberg (fig. 6).

The material described here as subspecies *drakensbergense* has previously been confused with *A. aethiopicum* s.l. but it can be readily distinguished from the latter species by its markedley cuneate truncate pinnules and by the absence of small scales and fibrils from the undersurfaces of the pinnae except for a few on the costa. It differs from subspecies *splendens* by its darker brown rhizome scales which are made up of larger cells (fig. 2), by its smaller narrower fronds with a green rachis and with less dissected pinnae bearing cuneate straight-sided truncate pinnules and by its larger and darker brown spores (Appendix I, Plate I, 4 and 5). In addition subspecies *drakensbergense* is generally found at higher altitudes than subspecies *splendens*.

2. *A. multiforme* Kr. Ann. des K. and K. Nat. Hof., **15**: 1 (1900).

This species was first described from a specimen collected by Krook from Newmarket (N. of Kokstad, Mt. Currie Div., Cape Prov.) and the octoploid material from Askeaton (Appendix I, fig. 3) agrees well with the type specimen in all respects including spore size.

Sim (1915) reduced *A. multiforme* to synonymy under his *A. cuneatum* Lam. and subsequent workers have included the material under *A. splendens* (subspecies *splendens*). It is altogether a smaller plant than *A. splendens* subspecies *splendens* with darker brown rhizome scales which are made up of much larger cells (fig. 2). The fronds are thicker in texture and the smaller pinnae are much less dissected and bear more compact rounded pinnules which are usually entire with more or less truncate apices. The spores are much larger and slightly darker (Appendix I, Plate I, 6).
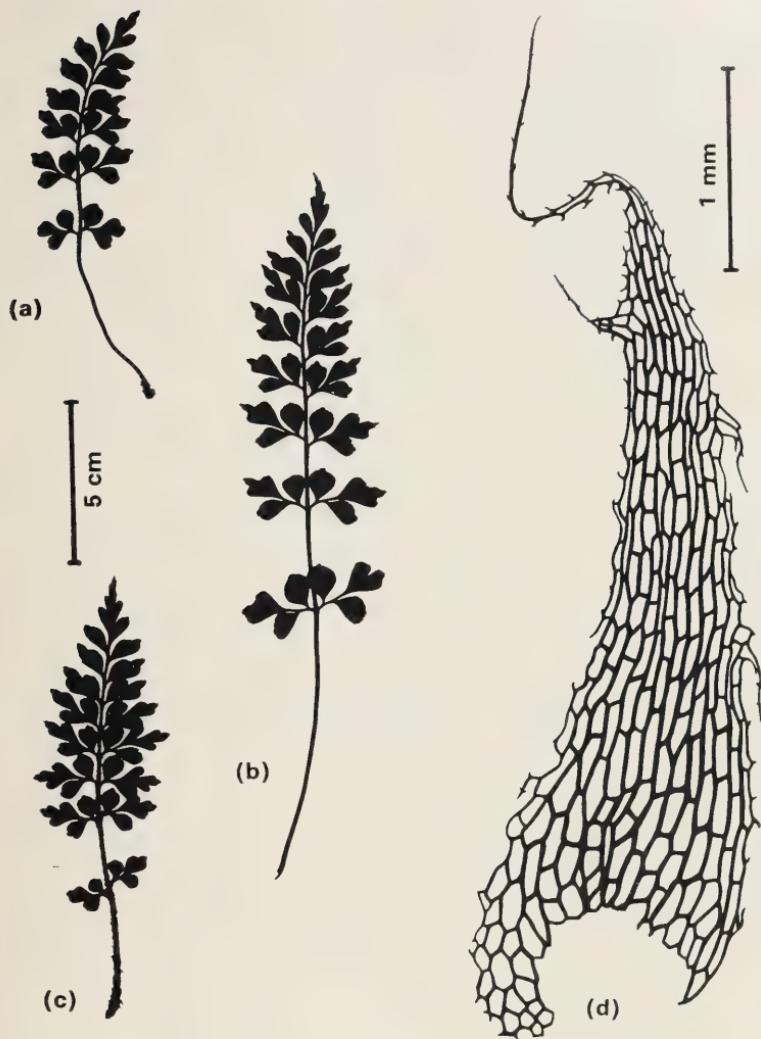
FIG. 3.
Silhouettes of fronds and a rhizome scale of *A. multiforme*. Fronds half natural size.
a) and b) wild material, B 108, Askeaton. c) Frond from cultivated plant B 108 Askeaton.
d) Rhizome scale B 108 Askeaton.

A. multiforme also differs ecologically from *A. splendens* subspecies *splendens*. While the latter is basically a forest taxon, *A. multiforme* is a rock crevice fern of drier areas. It is usually associated with rocky outcrops, often doleritic, in open grassland and bush areas sometimes growing with *Aloe*, *Euphorbia* and *Crassula* species. In the locality near Askeaton the plants were almost completely dried up in November and could easily have been overlooked. Other ferns in the same locality included representatives of some of the 'drier' country genera such as *Pellaea*, *Notholaena* and *Cheilanthes*.

The only other taxa likely to be confused with *A. multiforme* is *A. splendens* subspecies *drakensbergense* but the latter can be distinguished by its longer narrower fronds with a completely green rachis and by its more dissected pinnae bearing cuneate straight-sided pinnules. The spores are also smaller than those of *A. multiforme* (Appendix I, Plate I, 5 and 6).

The morphological, ecological and cytological differences between this material and *A. splendens* it is felt are sufficient to justify restoring its specific status.

A list of herbarium material which is attributed to *A. multiforme* may be found in Appendix II and the distribution is shown in fig. 6.

THE HYBRIDISATION PROGRAMME

The following wild gatherings have been used in the hybridisation experiments:

1) *A. splendens* subspecies *splendens*. 4x, Braithwaite 71, Pirie Forest, King Williams Town, Cape Province.

2) *A. splendens* subspecies *drakensbergense* 4x, Edwards s.n., Impendhle, Natal.

3) *A. multiforme* 8x Braithwaite 108, Nr. Askeaton, Xalanga Div., Cape Province.

4) *A. aethiopicum* s.l. 4x McNeil s.n., Transvaal.

The procedures used in the hybridisation programme have been fully described by Lovis (1969) and need not be repeated here. Chromosome preparations have been made using the acetocarmine squash method for fern spore mother cells described by Manton (1950).

The results of the hybridisation programme, giving details of the hybridisations attempted and the cytological information from the successful combinations, are assembled in Table I.

At the tetraploid level it is immediately evident from the percentage success data in Table I (items 1–3) that, while it is relatively easy to synthesise hybrids

FIG. 4.

Silhouettes of fronds from tetraploid hybrids between the subspecies of *A. splendens*. All half natural size. a), b) and c) ♀ subspecies *drakensbergense* Edwards s.n., Impendhle X ♂ subspecies *splendens* B 71 Pirie Forest. Three fronds from hybrid AB 648A.
d) and e) Reciprocal cross. Fronds from young plants. d) AB 571A. e) AB 571B.

(a)

(b)

(c)

5 cm

(e)

(f)
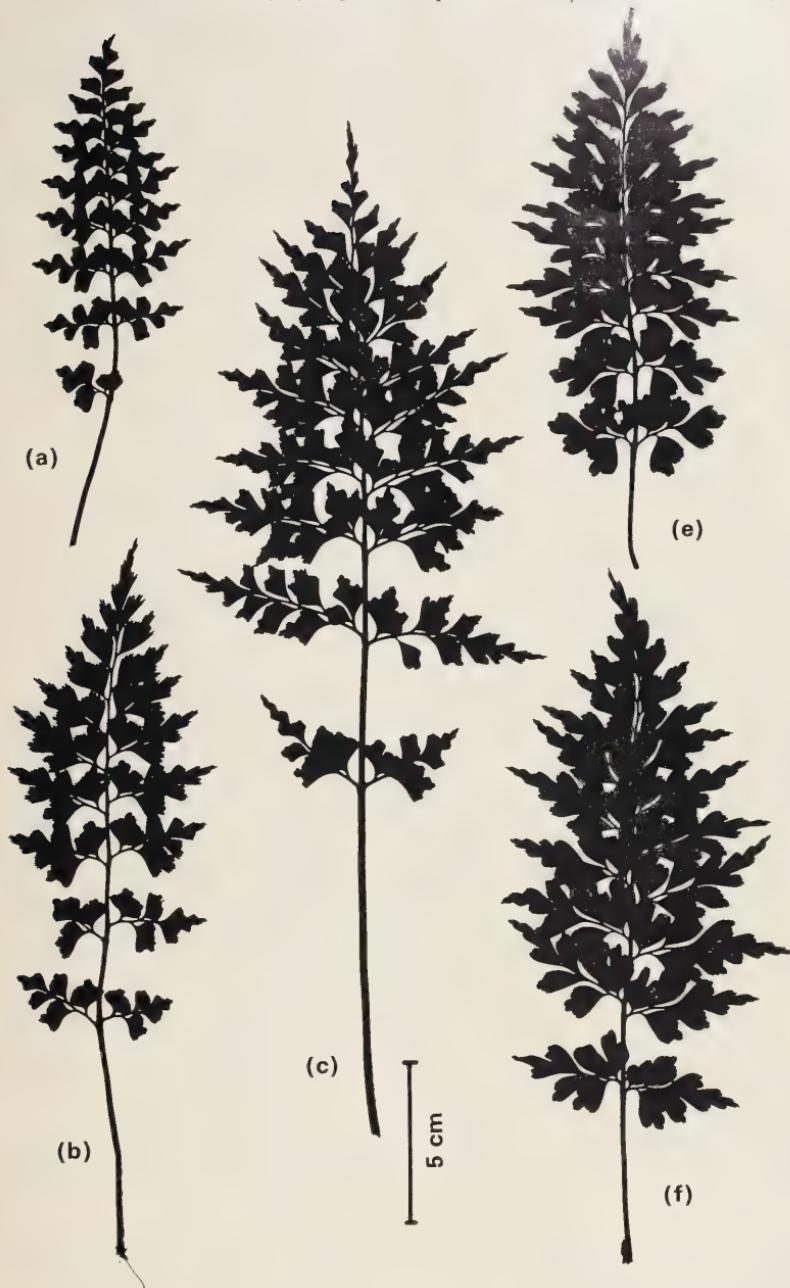
between the two subspecies of *A. splendens*, it is much more difficult to combine either of these subspecies with tetraploid *A. aethiopicum* from South Africa. In fact it has so far not been possible to synthesise a hybrid between *A. splendens* subsp. *drakensbergense* and *A. aethiopicum*.

TABLE 1

Details of hybridisation experiments involving *A. splendens*, *A. multiforme* and tetraploid *A. aethiopicum*.

	No. of prothalli	No. of hybrids	%age success	Chrom. pairing at meiosis
Tetraploid hybrids				
1) ♀ A. splendens subsp. splendens X ♂ A. aethiopicum 4x. Reciprocal hybrid	50 ⎱ 20 ⎰ 70	1 ⎱ 7 ⎰ 8	11%	Virtually no pairing. 144 univalents
2) ♀ A. aethiopicum 4x X ♂ A. splendens subsp. drakensbergense.	48	0	0%	– – – –
3) ♀ A. splendens subsp. drakensbergense. X ♂ A. splendens subsp. splendens. Reciprocal hybrid	16 ⎱ 32 ⎰ 40	13 ⎱ 17 ⎰ 30	75%	Complete pairing. 72 bivalents.
Hexaploid hybrids				
4) ♀ A. multiforme X ♂ A. splendens subsp. splendens.	8	5	63%	71–72 paired groups (trivalent & bivalent) + 48–54 univalents.
5) ♀ A. multiforme X ♂ A. splendens subsp. drakensbergense.	22	12	55%	70–72 paired groups (trivalent & bivalent) + 45–51 univalents.

The tetraploid hybrids between the two subspecies of *A. splendens* were vigorous and morphologically intermediate between the two parents although the characters of the female parent tended to predominate so that the reciprocal hybrids differed slightly (fig. 4). Two hybrids synthesised using subspecies *drakensbergense* as the female parent and one sythesised in the other direction have been cytologically examined. In each case meiosis was regular with 72 bivalents. The hybrids produced well filled spores and those from one plant which has been tested have shown good germination, but an F2 generation has not yet been raised.

In contrast the tetraploid hybrids between *A. splendens* subspecies *splendens* and *A. aethiopicum* show virtually no chromosome pairing at meiosis. In two hybrids examined in detail the chromosomes appeared as 144 univalents and the plants were almost completely sterile except for a few apparently well filled spores.

The two different types of meiotic behaviour found in the tetraploid hybrids are illustrated in Plate I, 1 and 2.

The hexaploid hybrids (items 4 and 5 in Table I) involving *A. multiforme* and the two subspecies of *A. splendens* are relatively easily synthesised; the hybridisation attempts for both crosses being more than 50% successful. The hybrids were vigorous but sterile and two representatives of each cross have been investigated cytologically.

The chromosome pairing in each of the hexaploid combinations is essentially similar so that their cytology may be conveniently considered together. A representative cell from the hybrid between *A. multiforme* and *A. splendens* subspecies *splendens* is shown in Plate I, 3 and an analysis of the same cell is shown in fig. 5. This cell shows 72 paired groups (21 trivalents + 51 bivalents) and 51

FIG. 5.
Chromosome pairing in a hexaploid hybrid between *A. multiforme* B 108, Askeaton and *A. splendens* subsp. *splendens* B 71, Pirie Forest. Explanatory diagram for Plate I, 3 showing 21 trivalents in black and arrowed, 51 bivalents in black and 51 univalents in outline. (X 1500).

univalents. The analyses obtained for both hybrid combinations fall into the range of 70—72 paired groups and 45—54 univalents. In all the cells analysed there are a significant number of trivalents, although it is not always easy to identify them with complete accuracy when dealing with chromosome numbers as high as in these hybrids. However, the number of univalents in all the cells analysed is significantly much lower than 72 (the number which would be expected if all the paired groups were bivalent) which indicates that between 18 and 27 of the paired groups are tricelent.

INTERPRETATION AND DISCUSSION OF THE OBSERVATIONS

It is evident from the percentage success data of the hybridisation attempts at the tetraploid level in Table I that there are considerable differences in the compatibility on the one hand, between the two subspecies of *A. splendens* and on the other, between these two subspecies and tetraploid *A. aethiopicum*. These differences suggest that the affinities of the material described as *A. splendens* subspecies *drakensbergense* do not lie with *A. aethiopicum* with which it has been confused, but rather with *A. splendens*.

The regular chromosome pairing observed in the hybrids between the two subspecies of *A. splendens* provides further evidence of their close relationship, although the 72 bivalents appearing in hybrids can be interpreted in two ways. The 72 chromosomes contributed by the gametes of each parent may be sufficiently homologous to allow them to pair completely and form 72 bivalents in the hybrid. Alternatively, the 72 chromosomes contributed by each parent may be completely non-homologous but are capable of pairing among themselves (i.e. autosyndetic pairing). In this case the chromosomes of each parental gamete contribute 36 bivalents to the total of 72 bivalents found in the hybrid; thus resembling the cytological behaviour of certain European tetraploid hybrids in *Asplenium* (Lovis, 1964). However, the virtual lack of any chromosome pairing in the hybrids between *A. splendens* and *A. aethiopicum* indicates that the chromosomes of subspecies *splendens* are not capable of any appreciable autosyndesis. The only interpretation, therefore, which is consistent with the facts as they are at present known is that the chromosomes of the two subspecies are essentially homologous and are capable of pairing completely in the hybrids to form 72 bivalents.

On the other hand the virtual absence of any chromosome pairing in the tetraploid hybrids involving tetraploid *A. aethiopicum* strongly suggests that there is little or no homology between the chromosomes of *A. splendens* and *A. aethiopicum*.

The combined evidence from the tetraploid hybrids thus emphasises the distinctness of *A. aethiopicum* from *A. splendens* and confirms a close relation-

FIG. 6.

Map to show the distribution of *A. splendens* subsp. *splendens* (black circles), *A. splendens* subsp. *drakensbergense* (open circles) and *A. multiforme* (half black circles).

ship of the material treated here as *A. splendens* subspecies *drakensbergense* and *A. splendens* subspecies *splendens*.

There is at present little or no evidence for any cytogenetic differentiation which is sufficient to produce a sterility barrier within *A. splendens* at the tetraploid level. The F1 hybrid between the two tetraploid forms is fully fertile as far as can be judged from spore output and spore germination. The two tetraploids, therefore, may be regarded as members of the same ecospecies (Turesson, 1922, 1929) and, in consequence, have been treated as members of the same taxonomic species. Nevertheless there has been considerable morphological and ecological differentiation between the two tetraploids which merits taxonomic recognition at the infraspecific level. The two taxonomic subspecies which have been recognised may well represent morphologically distinct ecotypes, but before their precise relationship can be determined it is clearly desirable to raise an F2 generation.

Turning next to the cytology of the hexaploid hybrids (items 4 and 5, Table I) involving *A. multiforme*, the meiotic pairing for both crosses falls within the range of 70—72 paired groups (including 18—27 trivalents) and 45—54 univalents. The pairing in these hybrids is open to alternative interpretation, but in view of the close morphological relationship of the parental taxa it seems reasonable to suppose in both cases that maximum pairing is occurring between the 72 chromosomes contributed by the tetraploids and 72 of the 144 chromosomes of *A. multiforme*. If this is the case then any pairing in excess of 72 bivalents can only be accounted for by autosyndetic pairing among the chromosomes contributed by *A. multiforme*. Thus the presence of 18–27 trivalents reflects the minimum number of pairing homologies which exist in the chromosome complement of the octoploid. The full extent of the autosyndetic capacity of the chromosomes of *A. multiforme* cannot be ascertained from the present hybrids, but it is probably much greater than that indicated in the interpretation above since it is unlikely to be fully expressed as trivalents in these hexaploid hybrids. It can only be determined by either crossing *A. multiforme* with a totally unrelated species or by producing a tetraploid plant by inducing apogamy in the gametophyte of *A. multiforme*.

It is clear from the meiotic behaviour of the hexaploid hybrids that there is an equally close relationship between the two tetraploids and the octoploid and that there are considerable homologies among the gametic set of chromosomes of the octoploid. These homologies are sufficient to rule out the possibility of a true allopolyploid* origin for *A. multiforme* and suggest it is either an autopolyploid* (including intervarietal autopolyploid*) or a segmental allopolyploid* relative to the tetraploid genome.† On this interpretation, designating the haploid set of chromosomes of the tetraploid as A, the genomic constitution of *A. multiforme* can be expressed as AAAA where the genomes are completely homologous and

capable of pairing completely under suitable conditions or AAA1A1 where the genomes A and A1 are differentiated to the extent where they are only partially homologous and not capable of pairing completely. It should however be emphasised that the precise autosyndetic capacity of *A. multiforme* remains to be demonstrated and until this is done it is not possible on the direct cytological evidence available at present to exclude either of these possibilities. It will be necessary to suspend judgement until other evidence on the origin of *A. multiforme* has been considered.

A. multiforme is morphologically somewhat intermediate between *A. splendens* subsp. *splendens* and subsp. *drakensbergense*. Its rhizome scales, frond size and texture, degree of dissection of the pinnae and its truncated pinnules all resemble subspecies *drakensbergense* more closely but it possesses in common with subspecies *splendens* rounded pinnules and a rachis which is dark on the undersurface for at least half its length. It also occupies an intermediate range of altitude from 2 600—5 800 feet, while subspecies *splendens* is found from 80—5 000 feet and subspecies *drakensbergense* from 5 000—9 000 feet, so that its distribution tends to lie between those of the two tetraploids (fig. 6). These facts would seem to preclude a strict autopolyploid origin of *A. multiforme* from a single tetraploid type and indicates that both tetraploids have been involved in the origin of the octoploid. Since the two tetraploids contain essentially homologous chromosomes and apparently belong to the same ecospecies, such an origin would suggest that *A. multiforme* is an intervarietal autopolyploid rather than a segmental allopolyploid. There is, therefore only one conclusion which is consistent with morphological and ecological evidence and with the cytological data from the hybrids, namely, that *A. multiforme* is an intervarietal autopolyploid

* The classification of polyploids into four main types—*autopolyploids, segmental allopolyploids, true* or *genomic allopolyploids* and *autoallopolyploids*—by Stebbins (1947, 1950) is being adopted here. By *autopolyploid* is meant a polyploid containing two or more pairs of genomes made up of completely homologous chromosomes which are capable of pairing completely under suitable conditions and produce fertility when present together in the diploid condition. This is further subdivided into *strict autopolyploids* which have arisen from a single diploid type and *intervarietal autopolyploids* which have arisen from fertile diploid hybrids between morphologically and ecologically differentiated diploid types. A *segmental allopolyploid* is a polyploid containing two or more pairs of genomes made up of completely or partially homologous chromosomes which are able to pair all or a substantial number of their chromosomes under suitable conditions, but the genomes are differentiated in respect of a sufficiently large number of genes, chromosome segments or whole chromosomes to produce sterility when in the diploid condition. *True* or *genomic allopolyploidy* denotes the presence of two or more pairs of genomes made up of non-homologous chromosomes which are so different that they are unable to pair in the diploid condition. An *autoallopolyploid* contains more than two pairs of genomes and combines the characteristics of autopolyploids and allopolyploids.

† The evolution of a complex would normally be considered in terms of the basic or monoploid chromosome number of the genus, which in Asplenium is 36 (Manton, 1950). However, no diploids with 36 chromosomes at meiosis are known in either the group under investigation or any of its relatives, so that its evolution can only be usefully discussed at present in terms of the lowest level of polyploidy—the tetraploid.

which has arisen by the doubling of the chromosome complement of a hybrid or hybrid segregate between the two morphologically and ecologically differentiated subspecies of *A. splendens*.

A. multiforme normally shows 144 bivalents at meiosis although one spore mother cell has been observed with a single trivalent and an unpaired chromosome. The almost complete absence of multivalents from the wild material would suggest that its autosyndetic capacity is normally being kept in check by a genetical mechanism suppressing the formation of multivalents. It is now well established that meiosis is subject to genic control and it is not difficult to visualise such a mechanism appearing in natural populations where selection pressure is favouring increased fertility. The diploidised condition of *A. multiforme* would be in agreement with that found in a number of polyploids in the flowering plants and ferns, including several tetraploid *Aspleniums* (Lovis, 1964; Lovis et al, 1969; Lovis and Reichstein, 1969), which are known to be autopolyploids but form only bivalents at meiosis.

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Details of the material which has been cytologically examined.

Locality	Collector and Number	Cytology	Spore size
A. splendens Kze subsp. splendens			
Transvaal, S. Africa	McNeil s.n.	$n = 72$	
Ngome Ft., Ngotshe Div., Natal, S. Africa	Braithwaite 41	$n = 72$	33,2 ± 2,54
Oribi Gorge, Port Shepstone Div., Natal, S. Africa	Braithwaite 59	$n = 72$	34,0 ± 2,27
Pirie Ft., King Williams Town, Cape, S. Africa	Braithwaite 71	$n = 72$	33,7 ± 2,32
Magoebas Kloof, Tzaneen, Pietersberg Div., Transvaal, S. Africa . . .	Braithwaite 249	$n = 72$	33,4 ± 2,28
Woodbush Ft. Reserve, Pietersberg Div., Transvaal, S. Africa	Braithwaite 259	$n = 72$	34,9 ± 2,50
A. splendens Kze subspecies drakensbergense A. Braith. subsp. nov.			
Impendhle, Natal, S. Africa	Edwards s.n.	$n = 72$	40,3 ± 3,92
Ndedema area, Drakensberg, Bergville Div., Natal, S. Africa	Esterhuysen	$n = 72$	40,2 ± 3,95
(live plant collected at same time as Esterhuysen 28501, BOL)			
A. multiforme Kr.			
Nr. Askeaton, Xalanga Div., Cape, S. Africa	Braithwaite 108	$n = 72$	47,5 ± 3,90

Herbarium specimens of the material listed will be deposited at the British Museum (Natural History), London, and the Bolus Herbarium, University of Cape Town.

Herbarium specimens attributed to *A. splendens* Kze subspecies *drakensbergense* A. Braith. subsp. nov.

Natal: Impendhle, 5 200′, 2-vi-45. *Clarkson* 165. Mixed collection with *A. aethiopicum* s.l. (NH); Cathedral Peak area, Drakensberg, Weenen Div., shallow soil on rock in scree in kloofs, 7–8 000′, July 1949. *Esterhuysen* 15519 (BOL); Injasuti area, Drakensberg, Estcourt Div., rocky places, 5–6 000′, July 1956. *Esterhuysen* 26075 (BOL); Ndedema area, Drakensberg, Bergville Div., at base of rock, on slopes, on rocky banks and in recesses and screes, 7–9 000′, July 1960, *Esterhuysen* 28501 (BOL).

Lesotho: Banks of Caledon River, Leribe. *Dieterlen* 914 (PRE); without precise locality, 1861. *Cooper* 761 (PRE).

Herbarium specimens attributed to *A. multiforme* Kr.

Transvaal: Belfast. Under rocks along river. *Doidge* 29 (PRE); Carolina, c. 5 800′ *Rogers* 19730 (S–PB).

Natal: Vechtlager, Estcourt Div., Crest of rocky dolerite ridge. Crevice in boulders, c. 4 500′. 20-vii-44 *Acocks* 10502 (PRE, NH); Winters Kloof. In bush. *Doidge* s.n. (mixed collection) (PRE).

Cape: Stutterheim Commonage. Crevice in boulder. Rare. c. 2 600′, 19-iv-43 *Acocks* 9770 (PRE); Nr. Askeaton, Xalanga Div., Among rocks by roadside, c. 4 000′ 1-xi-60. *Braithwaite* 108 (BM, BOL); Nr. Askeaton, Xalanga Div., locally common in moist rock crevices on rock flush, c. 4 000′. 17-xii-55 *Schelpe* 5382 (BOL); Winston, Cathcart Div. Crevices in boulders on rocky dolerite ridge with Crassula. Locally common, c. 5 000′. *Acocks* 11396 (PRE); Kokstad, Mt. Currie Div. *Mogg* s.n. (PRE); Kamacho (locality unplaced) *Paterson* 646 (PRE).

A NOTE ON THE FUNGUS *ENDOGONE*

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Abstract

The recovery of *Endogone* spores from South African soils is reported for the first time.

Uittreksel

'N NOTA OOR DIE SWAM *ENDOGONE*.

Die verkryging van *Endogone* spore vanuit Suid-Afrikaanse grond word vir die eerste keer gerapporteer.

Of the several kinds of mycorrhizal fungi, the vesicular-arbuscular group belonging to the genus *Endogone* is by far the most common, infecting a wide range of plants (Gerdemann, 1968). Because they cannot be cultivated on culture media, they have received less attention than those fungi isolated by conventional methods. Although reported to be widespread, there is no record of their recovery from South African soils.

Rhizosphere soil together with the roots of plants were suspended in water and sieved to retrieve *Endogone* spores according to the method of Gerdemann and Nicolson (1963). Mesh diameters were 850, 250 and 125 μ. Washed material retained on the 125 μ sieve was suspended in water in a petri dish marked with thin parallel lines, 3–4 mm apart, on the outer surface. This enabled a more thorough search to be made under a stereo microscope (X25). *Endogone* spores were picked up with a capillary tube and suspended in water for examination under a compound microscope.

Several different spore types were observed. Noteworthy is the occurrence of a peculiar type (see Fig. 1) which resembles the honey-coloured sessile spores described recently in detail by Mosse (1970). This particular type was discovered by Gerdemann and Nicolson (1963) who described it briefly. To date reports of the occurrence of honey-coloured sessile spores have been from the United Kingdom (Gerdemann and Nicolson, 1963; Nicolson, 1967), West Pakistan (Khan, 1971), Australia and New Zealand (Mosse and Bowen, 1968). The specimen reported in the present study was found in the rhizosphere soil of a maize plant from the Outeniqua Experimental Farm, George, Cape Province. Large numbers of the type were observed.

This is a preliminary report of an investigation in progress.

100 μ

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FIG. 1.
A dense honey-coloured resting spore attached to the stalk of an empty mother spore.

TRANSPORT OF ^{14}C-INDOLEACETIC ACID ACROSS PEDICEL ABSCISSION ZONES IN *HIBISCUS*

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ABSTRACT

Studies using ^{14}C-indoleacetic acid (IAA) as a tracer in *Hibiscus* pedicel explants indicate that non-physiological concentrations of the hormone do not diffuse freely down the pedicel but tend to be immobilised by the tissue, especially at the pedicellar abscission zone. Transport at the terminal stage includes an acropetal component. Indication is that the tissue primarily responsible for movement of this hormone may be the cortical parenchyma. Transport varies directly with tissue age and inversely with IAA concentration.

UITTREKSEL

VERVOER VAN ^{14}C-INDOOLASYNSUUR OOR DIE AFSNYDINGSONE IN DIE BLOMSTEEL VAN *HIBISCUS*.

Studies met radioaktiewe indoolasynsuur (IAS) op blomsteeleksplante van *Hibiscus* toon dat nie-fisiologiese konsentrasies van dié hormoon nie vrylik in die blomsteel af diffundeer nie maar dat dit veral by die afsnydingstreek geïmmobiliseer word. Aanvanklik blyk dit dat vervoer van die hormoon 'n akropetale komponent insluit. Daar is 'n aanduiding dat die kortikale parenchiem dié weefsel is waarin die hormoon hoofsaaklik beweeg. Vervoer varieer direk met ouderdom van die weefsel en omgekeerd met konsenstrasie van die IAS.

INTRODUCTION

Abscission of fertilised and unfertilised ovaries in *Hibiscus* takes place at a well-defined abscission zone approximately 1 cm below the ovary. The zone is morphologically distinct as a constriction in the pedicel (Fig. 1) and is apparently present at the primordial stage of floral development. Since both floral buds and fruits are sources of endogenous auxin (Fawcett, 1961) which at certain concentrations acts as an abscission retardant (Addicott and Lynch, 1955), a transport study was undertaken in order to determine whether the abscission zone in *Hibiscus* presents a physical barrier to its free basipetal transport.

In a second series of experiments, the effects of age of tissue and of concentration of applied auxin were investigated, with the following in mind: firstly, the anatomy of the abscission process suggests that the transport properties of the tissue probably are age-dependent; and secondly, if transport is dependent on a limited number of transport sites as suggested by Leopold and de la Fuente (1968), the behaviour of high concentrations of hormone should differ from that of lower concentrations.

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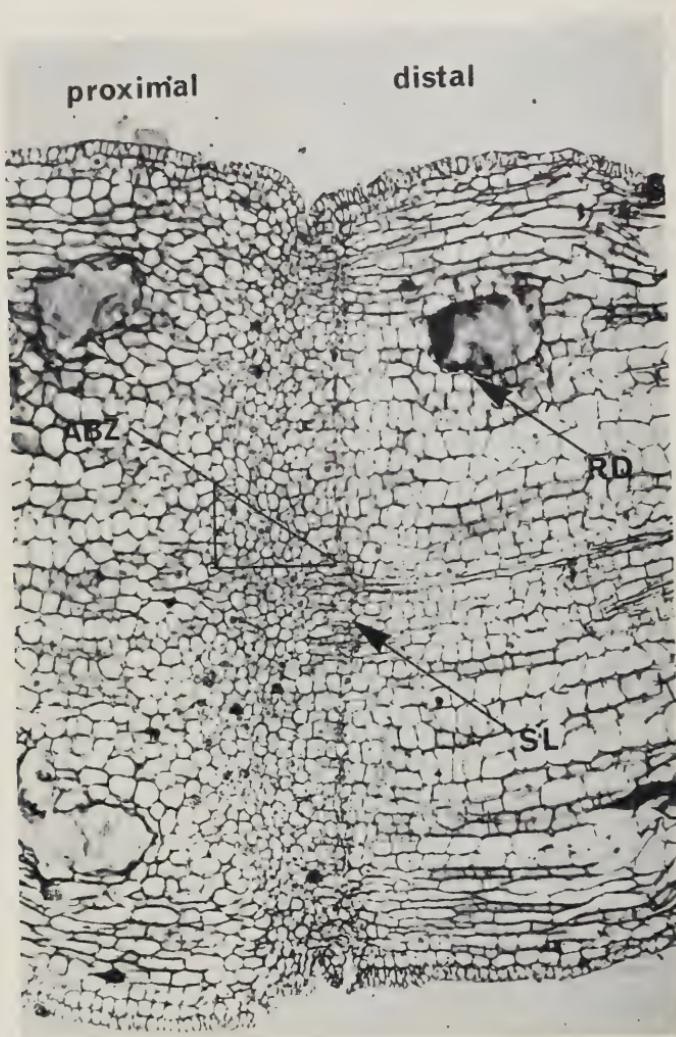
Fig. 1.
Longitudinal section of pedicel abscission zone at stage when corolla is fully extended, corresponding to Fig. 2b.
ABZ, abscission zone; RD, resin duct; SL, separation layer.

Since Jacobs and McCready (1967) showed that a cylinder of pith parenchyma of *Coleus* transported auxin at essentially the same velocity as a cylinder including vascular tissue, it was hoped also to gain some understanding of auxin movement in relation to type of tissue in the *Hibiscus* pedicel.

Materials and Methods

A carboxyl-labelled indoleacetic acid solution was monitored by liquid-scintillation counting. Transport was studied by means of the conventional agar donor-receiver block system (Kaldewey, 1968). Pedicels were selected from a single specimen shrub of *Hibiscus rosa-sinensis*, a hybrid in which seed is not set, as far as possible from the same area of the plant and at the same time of day. Pedicels of three different ages were selected, their age being determined by the appearance of the subtended flower (Fig. 2). Pedicels of median age (Fig. 2b), that is with fully extended corollas, were used for the initial transport experiments while pedicels from tightly-closed buds (Fig. 2a), and from ovaries which had shed their corollas (Fig. 2c), respectively, were used for later experiments in which the effects of age were investigated.
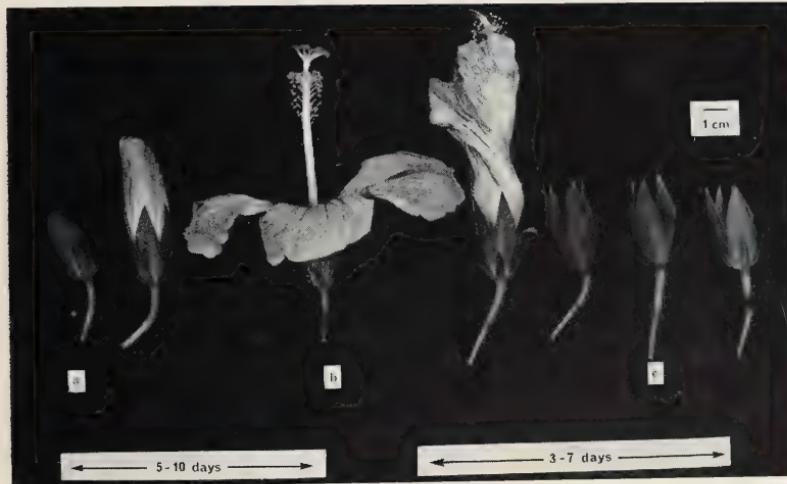
Fig. 2.
Floral development in *Hibiscus rosa-sinensis*.
a, bud stage; b, mature stage; and c, pre-abscission stage.

Identical 9 mm-pedicel segments were cut and immediately placed with the morphological apex up between similar 50 mm³ blocks of 3 per cent agar, to the upper of which was then applied a 20-μl droplet of ^{14}C-indoleacetic acid (^{14}C-IAA) solution. This block, the donor, was replaced in later experiments by a

block in which an identical amount of labelled auxin had been incorporated during preparation of the agar; this technique was found to give improved reproducibility. In early experiments, where the explants were placed with the morphological base upward, no downward transport of radio-activity was detectable above the background value after 60 minutes.
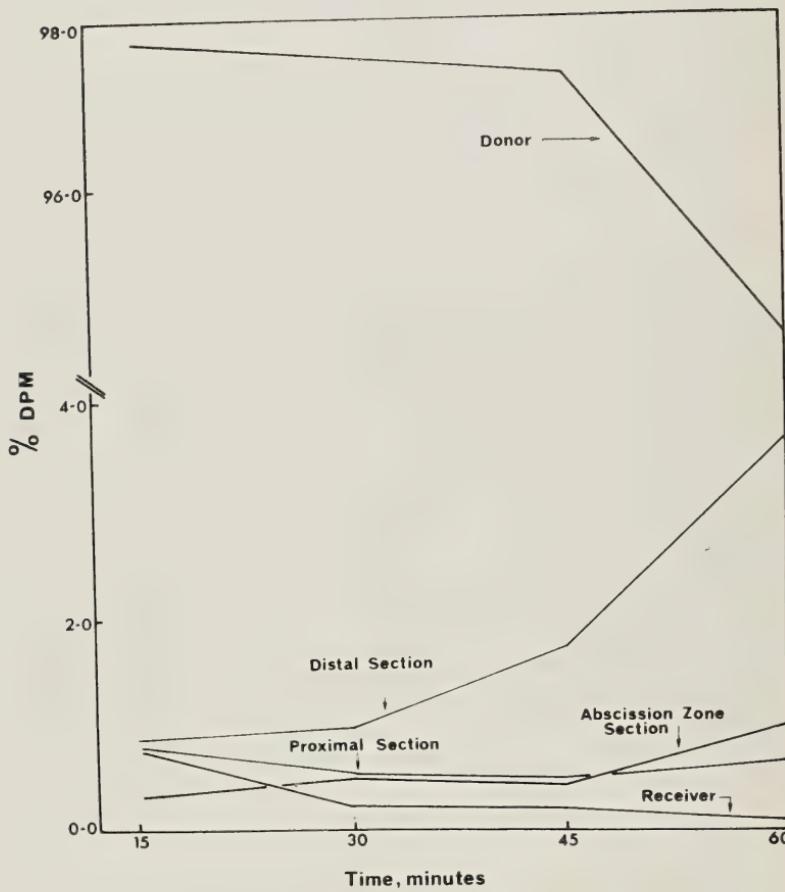
FIG. 3.
Distribution of radioactivity in donor-receiver system during a 60-minute transport period.

The ^{14}C-IAA solution used for the initial experiments had an activity of ca. $1,0 \times 10^4$ dpm (5,0 nCi) per 10 μl; this solution was used in subsequent experiments as the "high-activity" solution as opposed to a "low-activity" solution of ca. $4,5 \times 10^2$ dpm (0,2 nCi) per 10 μl.

After the duration of a specified transport period, the donor and receiver blocks were removed and each dissolved in 15 ml scintillation medium in a vial. The explant was then cut into three identical 3 mm segments, the median of which thus included the abscission zone, and each was macerated in 2 ml absolute ethanol in a vial for a standard period of 5 minutes. In studies involving extractable and non-extractable auxin, the tissue debris and the supernatant ethanol were separated at this stage. Fifteen ml scintillation medium was then added to each vial. The scintillation medium consisted of: naphthalene AR 60 g, PPO 4 g, dimethyl POPOP 200 mg, absolute ethanol 125 ml, ethylene glycol 20 ml, and toluene AR to 1 000 ml.

Activity per sample was counted in a Nuclear-Chicago Unilux II liquid scintillation counter and, after correcting for counting efficiency, expressed as a percentage of the system's total activity. The petri dishes which had been in contact with the receiver blocks were washed with ethanol and the washings examined for activity; in no case, however, did this exceed the atmospheric background count by more than 10 %. These values were added to those obtained from the receiver blocks.

Sections of tissue, 5—10 μ thick, containing 1—2 nCi per ml of ^{14}C were exposed to an autoradiographic emulsion for 4–5 days in an attempt to localise the sites of radioactive auxin.

RESULTS AND DISCUSSION

Figures 3, 4 and 5 represent the results obtained in the preliminary transport experiments whereas Figs. 6 and 7 show the effects of age and hormone concentration on the transport system. Additional data from these experiments are summarised, in the accompanying table.

Results such as those shown in Fig. 4 indicate a small accumulation of auxin at the abscission zone, although comparison with Fig. 3 may suggest that this accumulation might be due to the basipetal transport of a concentration peak. Nevertheless, simple polar transport of a downward-moving pulse does not provide an adequate explanation for these results. Firstly, the decrease in activity of the donor in Fig. 3 is not matched by an increase in the receiver in; fact the activity of the receiver decreases after 15 minutes transport. Furthermore, Fig. 5 shows that an appreciable amount of the applied activity is not ethanol-extractable and remains associated with the tissue debris; it is thus effectively removed from the transport system.

TABLE 1.
Comparison between transport capacities of tissues of different ages.

Tissue/ Treatment	T(min)	Section (Activity as % dpm)				
		Donor	Distal	Abscission Zone	Proximal	Receiver
o/l	15 30	22,9 30,2	15,6 17,3	13,4 19,7	29,5 16,6	18,4 18,0
y/l	15 30	89,5 66,2	0,4 9,3	8,6 10,8	0,5 10,1	0,9 13,4
o/h	15	63,5	41,3	15,0	1,4	5,8
y/h	15	89,0	7,5	1,4	0,7	1,3
m/h	5 15 30 45 60	99,1 97,6 97,4 97,1 95,8	0,2 0,7 0,9 1,8 3,4	0,2 0,5 0,5 0,4 0,3	0,2 0,4 0,4 0,3 0,2	0,2 0,7 0,6 0,3 0,2

o, old tissue; m, mature tissue; y, young tissue; h, high applied auxin; 1, low applied auxin

Section Number
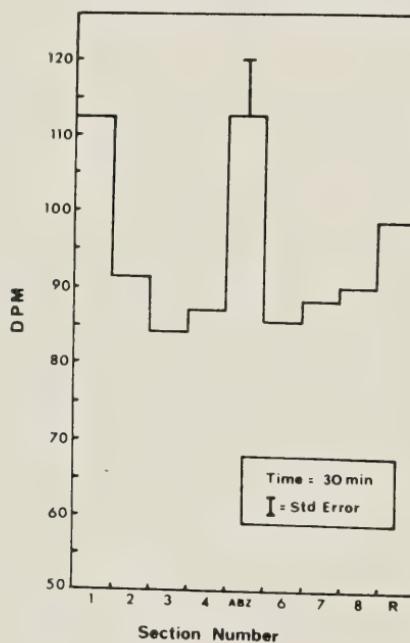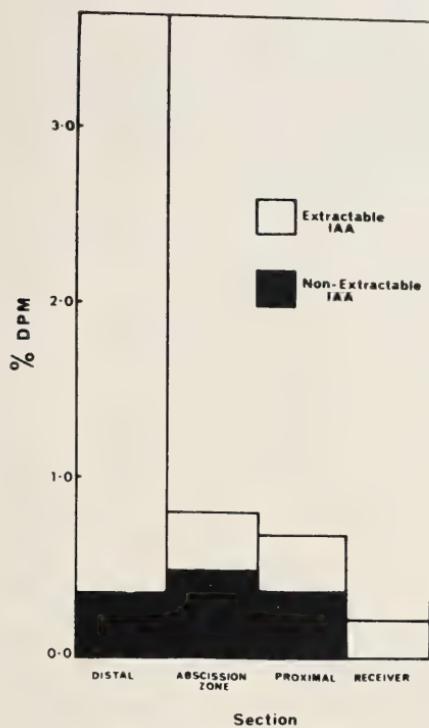
Fig. 5.
Radioactivity of extractable and non-extractable auxin after a 60-minute transport period.

The distributions shown in Figs. 6 and 7 suggest the following relationship between tissue age, auxin concentration, and rate of transport:

(i) very young pedicels are resistant to IAA transport, as is evident from the slow decrease in activity of the donor blocks;

(ii) in explants from older pedicels, however, there is a relatively rapid distribution of activity, suggesting that the tissue offers little resistance to free basipetal transport of IAA;

(iii) low auxin concentrations are distributed more rapidly than high ones in tissue of comparable age; however, high concentrations in old tissue are distributed more rapidly than low concentrations in young tissue;

Fig. 4.
Localisation of radioactivity in 1-mm sections after a transport period of 30 minutes. ABZ, abscission zone.

(iv) there is evidence of acropetal recycling (Goldsmith, 1969) and of enzymatic decarboxylation (Iversen and Aasheim, 1970) at the terminal step in both old and young tissue; and

(v) comparison with data obtained from mature tissue (see table) indicates that this is still more resistant to basipetal transport of high auxin concentrations than is very young tissue; in addition, acropetal recycling also occurs.
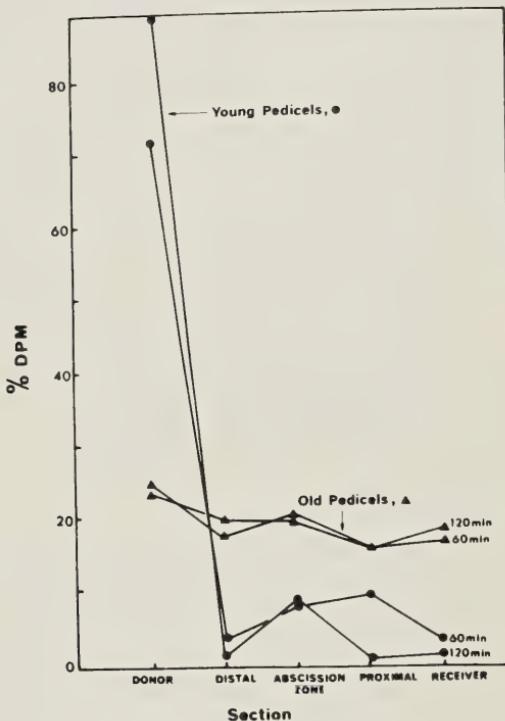
Fig. 6.

Transport profiles for low ^{14}C–IAA concentrations, that is 0,2 nCi/10 μl.

These observations are fully consistent with the view that abscission may be preceded by a reversal in auxin gradient across the abscission zone, and that the process includes a loss of cellular integrity.

A possible explanation for these results may be the following. During maturation and flowering, auxin is maintained at a high, abscission-retarding

level in the region distal to the abscission zone by the inactivation of the mechanism for basipetal transport between cells. Once abscission is initiated, however, this barrier is no longer operative and the auxin is freely transported across the abscission zone and towards auxin sinks in other organs.

A microscopic study of ^{14}C tracks in the developed autoradiographic emulsion in transverse sections of the pedicel, indicated a preference for the parenchyma of the cortex. However, a more definitive study is required to determine to what degree these tracks represent bound or free auxin, or degradation products.
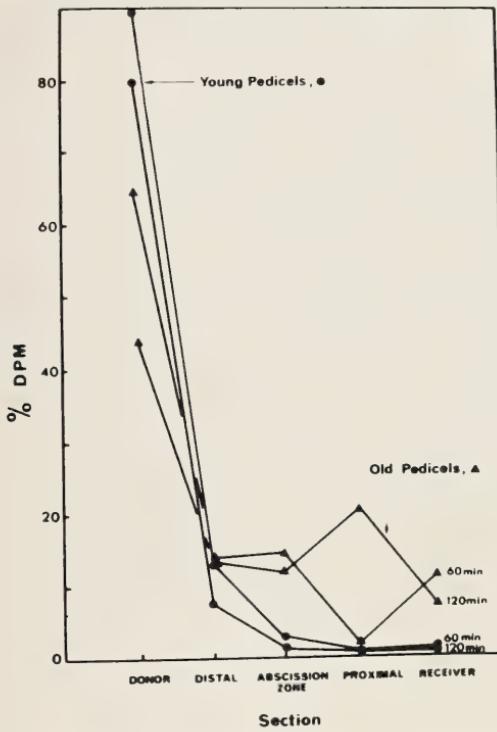
Fig. 7.

Transport profiles for high ^{14}C–IAA concentrations, that is 5,0 nCi/10 μl.

CONCLUSION

This study shows a small accumulatory effect in the pedicel abscission zone and some immobilisation, by metabolism or degradation, during auxin transport

down the pedicel. Some acropetal recycling and decarboxylation of auxin from the receiver block is also occurring. Transport is both age- and concentration-dependent. The highest transport values are obtained in old tissue to which low concentrations of ^{14}C-IAA are applied; the lowest, in mature tissue to which high concentrations of ^{14}C-IAA are applied. Very young tissue is more resistant to transport than old tissue, but less so than mature tissue.

ACKNOWLEDGMENTS

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A NOTE ON *HUERNIA VOLKARTII* WEDERM. & PEITSCH.

J. J. LAVRANOS

Huernia volkartii Wederm. & Peitsch. var. *repens* (Lavr.) Lavranos stat. nov. (Synonym, *H. repens* Lavr. in Jl S. Afr. Bot. 27, Part 1 (1961).

In volume 27, Part 1 of this journal, I described *Huernia repens*, based on plants collected in 1958 by Professor Schweickerdt near Garuso in Portuguese East Africa and drew attention to its close affinity to *H. volkartii*, then only known from Angola and Northern South West Africa.

Thanks to the activities of Leach, Plowes and others the known range of distribution of *H. volkartii* has been extended to Rhodesia, while the variety *nigeriana* Lavr. was described from Nigeria.

Meanwhile plants attributable to *H. repens* were also reported from Rhodesia, namely:

1.) On granite, in the mist belt at the Tokwe-Mukorzi dam, Victoria District, *A. G. Buckland* and *Plowes* 2555 (SRGH).

2.) At Kyle dam, *Plowes* 2483 (SRGH).

These recent gatherings prove that the ranges of the two taxa overlap. In view of this fact and taking also into account the truly vast range of distribution of *H. volkartii* and the very close similarity of the flower structure of it and *H. repens*, it seems advisable to reduce the latter to varietal rank under the former.

I am indebted to Mr. Leach for his having drawn my attention to the new distribution records of *H. volkartii* and its variety and for having suggested the advisability to change the status of the latter.

THE EFFECTS OF TEMPERATURE ON GERMINATION AND ETHANOL SOLUBLE CARBOHYDRATE PHYSIOLOGY OF SCLEROTIA OF *CLAVICEPS PURPUREA* (FR.) TUL. FROM THE SOUTH-WESTERN CAPE.

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ABSTRACT

Evidence is presented that although sclerotia of *Claviceps purpurea* from *Pennisetum macrourum* Trin. require a temperature treatment (0–10°C) to activate germination, long durations may reduce final percentage germination. Quantitative studies by means of gas liquid chromatography were made on the alchohol-soluble carbohydrates in sclerotia during dormancy, activation and germination. The carbohydrate physiology is discussed in relation to previous work on dormancy and germination of sclerotia of *C. purpurea*.

UITTREKSEL

DIE INVLOED VAN TEMPERATUUR OP DIE ONTKIEMING EN FISIOLOGIE VAN OPLOSBARE KOOLHIDRATE VAN SKLEROTIA VAN *CLAVICEPS PURPUREA* (FR.) TUL. VAN DIE SUID-WESTELIKE KAAP.

Bewys word gelewer dat alhoewel sklerotia van *Claviceps purpurea* vanaf *Pennisetum macrourum* Trin. 'n temperatuur behandeling (0–10°C) benodig om ontkieming aan die gang te sit, kan lang periodes die end-persentasie ontkieming verlaag. Deur middel van gas vloeistof chromatografie is kwantitatiewe werk gedoen op die etanol-oplosbare koolhidrate van sklerotia gedurende rus-, aktiverings en ontkiemings periode. Die fisiologie van koolhidrate is dan bespreek in die lig van vorige werk op rustende en ontkiemende sklerotia van *C. purpurea*.

INTRODUCTION

Recent studies (Mitchell & Cooke, 1968a) have indicated that dormancy in sclerotia of *Claviceps purpurea* (Fr.) Tul. is broken by a chilling treatment. Studies were performed on sclerotia from areas where normal frosting was a natural occurrence. Yet, epidemics may occur in regions where frosting is not common. A demonstration of sclerotia germinating without temperature activation has been published (Rajendron, 1966); and Hadley (1968) reported that a cold pre-treatment was not essential even though maximum germination was obtained with continuous incubation at 10°C.

Physiological investigations have shown that lipid utilization and changes in the endogenous carbohydrates take place during germination (Mitchell & Cooke, 1968b; Cooke & Mitchell, 1970). These investigations were carried out using sclerotia of *C. purpurea* collected from a pure stand of *Phalaris arundinaceae* L. Sclerotia were analysed for ethanol soluble carbohydrates by means

of paper chromatography and total sugars and total polyols were determined quantitatively (Cooke & Mitchell, 1969 and 1970). Further work is needed to substantiate these findings and a quantitative estimation of each component of the ethanol-soluble carbohydrates is necessary.

In this investigation sclerotia of *C. purpurea* from *Pennisetum macrourum* were collected from two regions in the South-western Cape, where frost conditions are not normal, although chilling temperatures do occur during the winter months. Mature sclerotia are seen in the host inflorescence between December and March. They subsequently fall onto the soil surface and are subjected to the normal environmental conditions during autumn and winter (May-October). A study was made of the temperature requirements necessary to break dormancy. Changes in the ethanol-soluble carbohydrates during dormancy, activation and germination using gas liquid chromatography were determined.

MATERIALS

Sclerotia were collected from Betty's Bay (CAPE 3418 BD) and Bain's Kloof (CAPE 3319 CA). Both sites are in a winter rainfall area and have typical fynbos vegetation. At Betty's Bay, the grass was present in marshland approximately $\frac{3}{4}$ kilometres from the coastline, while at Bain's Kloof it was found in small clumps in a valley bottom at an altitude of approximately 500 metres. Sclerotia were collected during February 1970, air-dried at room temperature and stored. The material was used from March to October, 1970.

TEMPERATURE ACTIVATION OF GERMINATION

Sclerotia were counted into batches of twenty, and each was placed on sterile damp filter paper in a closed Petri dish. Batches were incubated at 0°, 5° and 10°C and after 2, 4, 8, 12, 16 and 20 weeks a single batch of Bain's Kloof and Betty's Bay sclerotia was removed from each temperature treatment and sclerotia were allowed to germinate at 20°C. Further batches were given continuous incubation at 15°C and 20°C for 25 weeks. Germination was usually scored at daily intervals and a sclerotium was considered germinated when the first clava had emerged through the outer tissue. The results are expressed in Table 1.

A similar pattern of germination took place as in previous studies (Mitchell & Cooke, 1968a). At 0°, 5° and 10°C high germination levels occurred provided that the treatment was of sufficient duration. No germination occurred after continuous incubation at 20°C. At 15°C first signs of germination took place after 15 weeks, but at the end of the experiment only 10% (Bain's Kloof) and 15% (Betty's Bay) of the sclerotia had germinated.

TABLE 1

Final percentage germination and time (days) at room temperature to reach 50% of final germination after chilling at 0°, 5° and 10°C.

Site	Duration of Chilling	0°		5°		10°	
		Final % germination	Time for 50% of final germination (days)	Final % germination	Time for 50% of final germination (days)	Final % germi-	Time for 50% of final germination (days)
BETTY'S BAY	2 wks	0	—	30	24	5	14
	4 wks	10	11	70	13	85	18
	8 wks	55	11	80	15	65	13
	12 wks	75	11	85	8	75	7
	16 wks	60	22	80	15	85	4
	20 wks	20	7	15	3	60	—17
BAIN'S KLOOF	2 wks	0	—	5	42	5	16
	4 wks	0	—	50	17	55	27
	8 wks	50	14	70	9	55	25
	12 wks	75	11	60	23	65	12
	16 wks	80	27	55	17	65	22
	20 wks	45	6	30	40	75	— 6

At 0° and 5°C with increasing duration of incubation from 0 to 12 weeks, final percentage germination increased but at longer durations this resulted in reduced final germination figures. At 10°C after 16 weeks incubation there was 15% (Bain's Kloof) and 25% (Betty's Bay) germination and after 20 weeks incubation 65% (Bain's Kloof) and 55% (Betty's Bay) germinated before the sclerotia were transferred to room temperature.

CHANGES IN ETHANOL SOLUBLE CARBOHYDRATES

Sclerotia from Bain's Kloof and Betty's Bay were incubated on damp filter paper in closed Petri dishes at 5°C for 8 weeks. At the end of this period they were transferred to 20° and allowed to germinate. Further batches from Betty's Bay were incubated in a dormant state at 20°C for 12 weeks, transferred to 5°C for 8 weeks to be activated and then allowed to germinate at 20°C. The germination process was divided into four arbitrary stages (Table 2).

Every 3–4 weeks during dormancy and activation and at every germination stage, samples of sclerotia (180–200 mg fresh mass) were dried at 80°C for 6 hr., reweighed and plunged in 4 cm³ of boiling 80% ethanol. At stage 4 germination, clavae were dissected from the sclerotia and were treated as separate samples. Samples were ground and ethanol soluble sugars were extracted in 120 cm³

TABLE 2

Stages in germination of sclerotia of *C. purpurea.*

STAGE	Time (weeks) after Removal from 5°C	Morphological features
1.	1	No external signs of germination
2.	2	
3.	3	First clavae emerging
4.	4	Stromata present

80% ethanol using Soxhlet extractor. Extracts were then reduced at 40°C using a rotary evaporator. The residue was dissolved in water, deproteinized by the addition of barium hydroxide and zinc sulphate (Lewis & Harley, 1965) and deionized by means of a mixture of Dowex 1–8 and Dowex 50 W $\times$ 8 ion exchange resins. The filtrate was reduced to dryness and taken up in 20 cm³ of distilled water.

Sugars were then detected by gas-liquid chromatography. A known volume (approximately 5 cm³) was reduced and as an internal standard 1 mg of erythritol was added to each sample. Preliminary paper chromatography using similar methods as described by Cooke and Mitchell (1969) indicated an absence of erythritol in all the samples. The residue was redissolved in 1,0 cm³ of anhydrous pyridine (kept over KOH pellets).

The soluble carbohydrates were separated as their trimethyl silyl (TMS) derivatives, using a similar method to Sweeley et al (1963). The reaction time was 10 minutes and pyridine was blown off with nitrogen gas. The derivatives were redissolved in 1 cm³ of chloroform and centrifuged. 10 µl of supernatant was injected by means of a Hamilton microlitre syringe into a Pye series 104 gas chromatograph with a Philips PM8100 pen recorder. The columns contained Chromosorb W80–100 mesh as a solid support with a non-polar liquid phase, S.E. 52 (20% methyl phenyl silicone gum). The samples were run on a programme of 160°C for 15 minutes, followed by an increase of 3°C/minute up to 230°C and then a final isothermal run at 230°C for 36 minutes. Peak areas were determined by means of peak triangulation method. Appropriate markers of known concentration were also injected into the column and in the case of erythritol, arabinitol, fructose (combined anomers), glucose (combined anomers) and mannitol, peak areas were found to be linear in the range 0–1,4 mg/cm³ pyridine. Holligan and Drew (1971) have also demonstrated that calibration curves for a number of sugars are linear, by using the digital integration method. Each component except trehalose was calculated in terms of mole % of either total reducing sugars or total polyols.

Because of the poor detection response of trehalose and as no other oligosaccharide was present, trehalose was determined as the difference between

total sugars and reducing sugars. Total sugars in 1 cm³ aliquots of sample were determined quantitatively by the phenol-sulphuric acid method (Dubois et al, 1956), total reducing sugars using modified Nelson method (Somogyi, 1952) and total polyols using periodate consumption method (Lewis & Smith, 1967). The sugar components of each sample were then expressed as mg/g oven-dry weight.

Air-dried sclerotia contained trehalose, mannitol, arabinitol, glucose and fructose and the amounts of each from the two sites are shown in Table 3. Fructose has rarely been found in fungi (Adomako et al, 1971), but further paper chromatography analysis described elsewhere (Cooke & Mitchell, 1969) and the use of p- anisidine hydrochloride as the detection reagent (Hough et al, 1950) indicated the presence of fructose in the air-dried samples.

TABLE 3
Ethanol-soluble carbohydrates of air-dried sclerotia, and samples incubated for 4 weeks at 5°C.

Sites	Sample	Concentration mg/g dry weight				
		Trehalose	Mannitol	Fructose	Glucose	Arabinitol
Betty's Bay	Air-dried	47,90	2,15	8,80	2,73	1,60
	4 weeks at 5°C	13,90	3,99	1,59	3,59	0,16
Bain's Kloof	Air-dried	39,08	24,92	16,01	2,62	18,28
	4 weeks at 5°C	14,52	1,29	1,53	2,19	0,09

Changes during dormancy, activation and germination of trehalose, glucose and mannitol are expressed in Figures 1 and 2, which emphasize previous findings that major changes can be attributed to trehalose and mannitol (Cooke. and Mitchell, 1970). Much fructose, arabinitol and trehalose was lost during the initial incubation periods of dormancy and activation. Only one sample contained more than 1,0 mg of fructose/g dry weight after 4 weeks incubation; this was after 8 weeks at 5°C from Bain's Kloof site and 1,59 mg/g was detected. After 4 weeks incubation none of the samples contained more than 0,8 mg arabinitol/g dry weight. There was, therefore, a clear indication of both fructose and arabinitol disappearing very rapidly.

In the Betty's Bay samples there was a steady increase of mannitol during activation, but after removal to 20°C mannitol content of samples from both sites rose. In Betty's Bay samples this increase was from 14,2 to 25,9 mg/g and in the Bain's Kloof samples an increase from 2,0 to 29,1 mg/g was recorded. There were, however, differences in the trehalose contents during germination. In the Betty's Bay samples trehalose declined after 2 weeks germination process
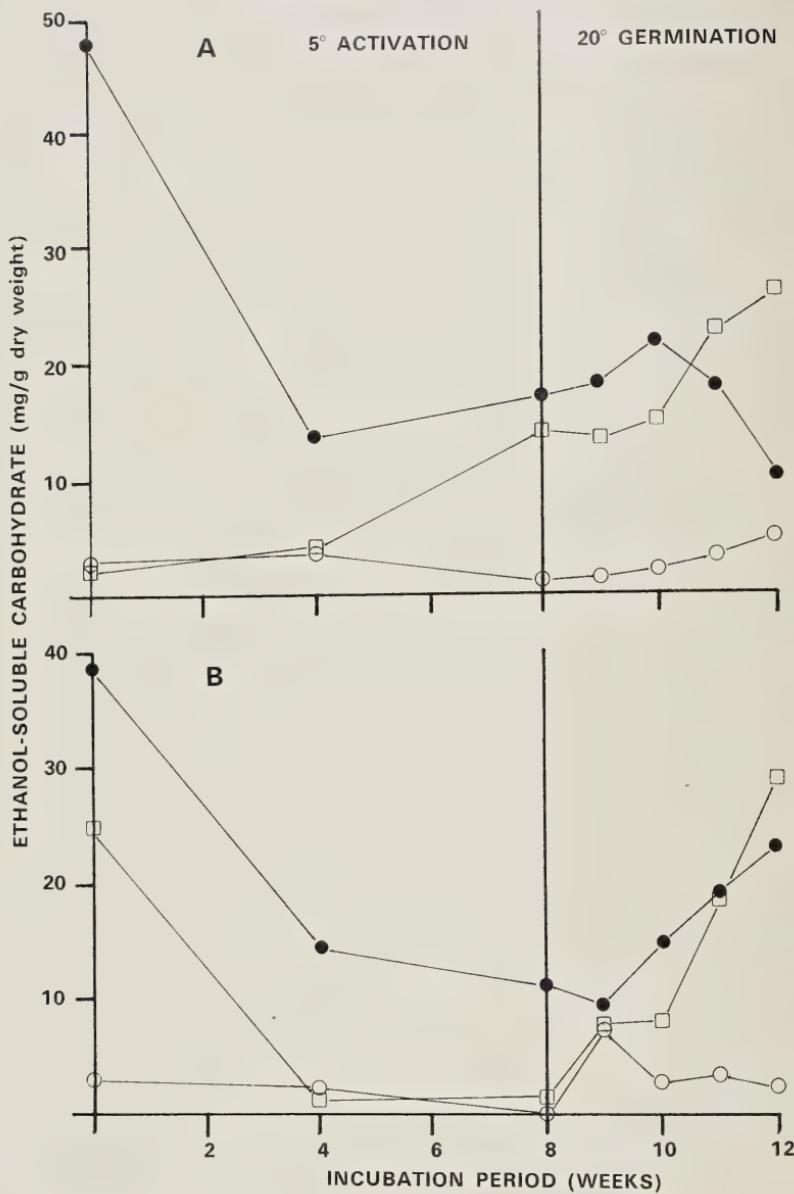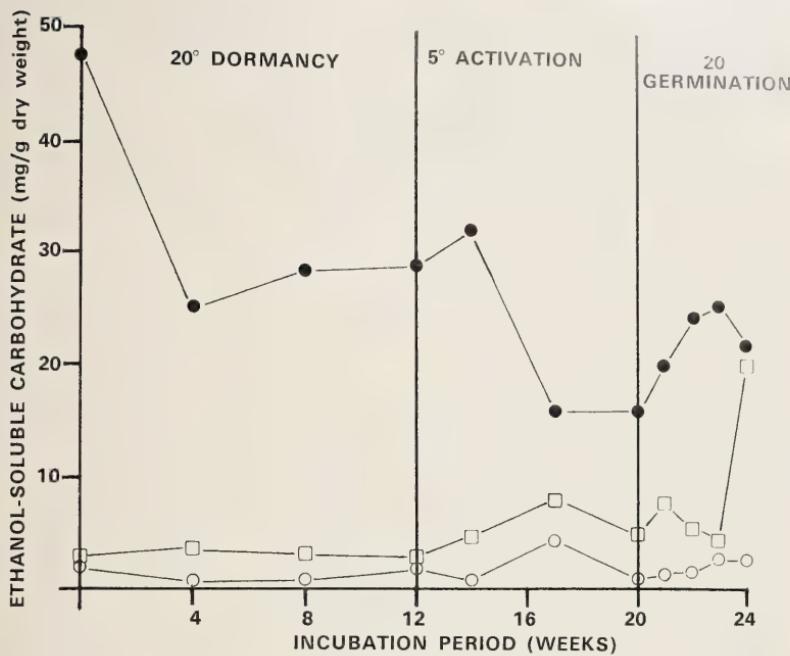
FIG. 2.
Changes in glucose, mannitol and trehalose during dormancy activation and germination in sclerotia of *C. purpurea* from Betty's Bay.
○ —— ○ Glucose □ —— □ Mannitol
● —— ● Trehalose.

from 21,5 to 9,82 mg/g whereas from Bain's Kloof trehalose content increased from 9,51 to 23,0 mg/g after one week's germination process. Dry weight of clavae as a percentage of total (sclerotium and clavae) dry weight and carbohydrate determinations as a percentage of the respective component (sclerotium and clavae combined) are expressed in Table 4. The ethanol-carbohydrate

FIG. 1.
Changes in glucose, mannitol and trehalose in sclerotia of *C. purpurea* during activation and germination.
A — ergots from Betty's Bay
B — ergots from Bain's Kloof
○ —— ○ glucose □ —— □ mannitol
● —— ● trehalose

contents of the clavae were found to be very high which has served to emphasize previous findings (Cooke and Mitchell, 1970), although determinations from S.W. Cape samples were not of the same magnitude.

TABLE 4

Dry weight and soluble carbohydrate contents of clavae in terms of % of total (sclerotium and clavae combined) of respective component.

Site	Dry weight	Trehalose	Mannitol	Glucose
Betty's Bay	18,0	59,6	45,6	42,6
X	11,3	31,8	43,2	39,0
Bain's Kloof	8,1	26,9	23,2	34,3

X—Samples incubated for 12 weeks at 20°C prior to 5°C activation

DISCUSSION

Sclerotia of *C. purpurea* from *P. macrourum* require a chilling treatment to activate germination. An inhibition of germination may occur over longer durations of treatment at the lower ranges of temperature (0°–5°C). At 10°C sclerotia were able to germinate after long durations of treatment before the sclerotia had been transferred to 20°C. Normal weather conditions during the winter months of the south-western Cape suggest that chilling is not frequent and occurs mainly at night time. Thus, in nature, activation of sclerotia may be a cumulative process, but stroma formation of chilled sclerotia takes place only when suitable temperatures (at 10°C and above) prevail for a long enough period.

There are profound changes in the ethanol-soluble carbohydrates during dormancy, activation and germination. The fructose and arabinitol present in sclerotia at the time of their formation disappeared very rapidly with incubation and they may lack an obvious metabolic role (Cooke & Mitchell, 1970). By analogy of lipid metabolism and dormancy of seeds, previous evidence has linked carbohydrate physiology with lipid catabolism (Cooke & Mitchell, 1970). Lipid content of air-dried sclerotia of *C. purpurea* from *P. macrourum* was found to be 48,3% using methods similar to those described in Mitchell & Cooke (1968b), but it is a matter of conjecture whether similar processes are taking place. Supporting the lipid-sugar-mannitol conversion is the rise in mannitol content during germination in sclerotia from both sites, but there were variations in the levels of trehalose. There was an increase in trehalose during germination in samples from Bain's Kloof, compared with a decrease in the samples from Betty's Bay. Glucose content is shown to be fairly steady

during the incubation stages, although any slight changes in glucose appear to be correlated with concomitant changes in trehalose and mannitol. Possibly conversions of glucose to either trehalose or mannitol may be so rapid that it would be difficult to detect, although enzyme studies would determine this. The 'sink' concept proposed by Cooke & Mitchell (1970) appears to be a feasible one in view of the high glucose, trehalose and mannitol contents of the clavae. An energy source is therefore easily available for normal sexual reproduction and formation and ejection of ascospores from the stroma.

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PROTEINS OF THE GENUS *LITHOPS* (AIZOACEAE): DEVELOP-MENTAL AND COMPARATIVE STUDIES

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Abstract

The protein constitutions of species of the genus *Lithops* were examined by acrylamide gel electrophoresis. Total protein patterns show a strong developmental dependence and little taxonomic utility. Individual isoenzyme patterns show no developmental dependence and appear to be species-specific and of systematic interest.

Uittreksel

PROTEÏNE VAN DIE GENUS *LITHOPS* (AIZOACEAE): ONTWIKKELING EN VERGELYKENDE STUDIES.

Die proteïn samestellings van spesies van die genus *Lithops* was ondersoek deur akrylamiedgel elektroforese. Totale proteïn patrone toon 'n sterk ontwikkelings afhanklikheid en min taksonomiese bruikbaarheid. Individuele isoensieme patrone toon geen ontwikkelings afhanklikheid nie en blyk om van spesies spesifieke en sistematiese belang te wees.

Introduction

The taxonomy of the genus *Lithops* has historically been based primarily on morphological characters (Jacobsen, 1960). Recently studies of the microscopic anatomy of members of this genus have been initiated to determine if additional systematic insights might be gained (Dugdale, 1966; 1968). In numerous taxa, however, morphological and anatomical data have proven insufficient to resolve adequately some systematic questions which arise. Recently comparative studies of chemical constituents, both micromolecular and macromolecular, of closely related species have provided additional information concerning systematic relationships among various plant taxa (Alston, 1967; Turner, 1969). One species of *Lithops* (*L. kuibisensis*) has been reported to contain flower pigments in the class known as betacyanins (Wohlpart and Mabry, 1968). This chemical evidence supports the argument that the family Aizoaceae, of which *Lithops* is a member, is properly placed in the order Centrospermae along with the other plant families to which betacyanin pigments are unique. The present work reports chemical data on a different class of chemical compounds, the proteins. When the total extractable protein from a plant sample is fractionated by zone electrophoresis on acrylamide gels and appropriately stained, a pattern of bands is observed which has been found in some plant taxa to be species-

specific and of diagnostic utility (Garber, 1965; Hart and Bhatia, 1967). To determine if such a situation obtains among various *Lithops* species, the present study was begun.

MATERIALS AND METHODS

Living plants and seeds were obtained from and identified by Mr. Chester Dugdale of Farleigh-Dickenson University, who had collected specimens in the field. Proteins were extracted from individual, mature plants by finely dicing the leaf material and grinding it with no further addition of water in a TenBroeck homogenizer. Natural tissue succulence provided adequate solvent for grinding. Sucrose was added to the homogenate to approximate a 20% solution and the homogenate was centrifuged (5 minutes at 1000xg) to remove cellular debris. The opalescent supernatant was layered directly as the electrophoretic sample. The small size of young seedlings necessitated pooling from 6 to 15 seedlings (depending on size and age) followed by grinding and preparation as above. Electrophoresis was carried out by standard methods of Ornstein and Davis (1962) at 3 milliamps per gel tube. Total protein was stained using Coomassie Blue (Chrambach, *et al.*, 1967). Enzyme specific assays were performed by the following methods: tyrosinase (polyphenol oxidase) (Davenport, 1964), alpha-esterase (Markert and Moller, 1959), lactate dehydrogenase (LDH) (Laycock *et al.*, 1965) and indophenol oxidase (Davenport, 1964).

RESULTS AND DISCUSSION

Developmental Studies

Current ontogenetic theory proposes that the process of differentiation is controlled by the selective synthesis of particular enzymatic proteins at different stages of development. It would be reasonable to expect that the protein banding pattern exhibited would be a function of the developmental stage of the organism. This has been observed in maize (Hamill and Brewbaker, 1969).

When *Lithops* seedlings from a single seeding of several species were examined for total protein pattern at intervals of several weeks, differences in the pattern could be detected with increasing age. Figures 1 and 2 show developmental changes in total protein pattern and compare seedling pattern with the pattern observed from seed material or mature plants where these were available. Marked developmental changes occur and, in general, the number of detectable bands tends to decrease with increasing age. It should be noted that this presents a serious problem in utilizing band pattern comparisons as a comparative taxonomic character since careful precautions would be required to insure that all taxa compared are at similar stages in development.
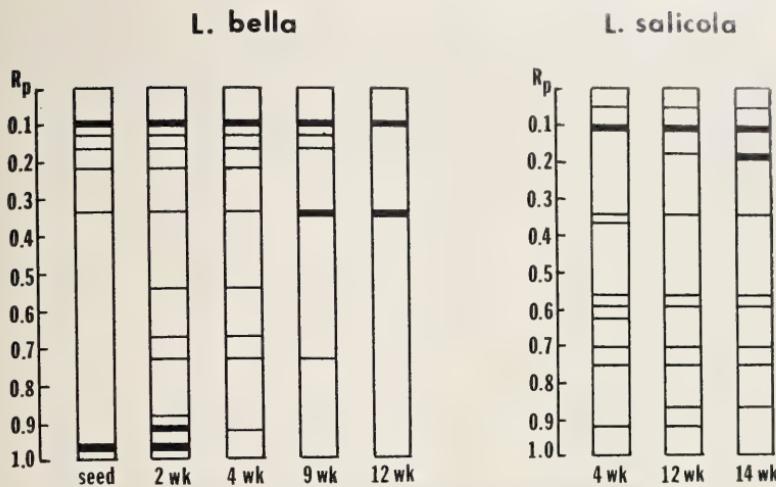
FIG. 1. Developmental changes in total protein in *Lithops bella* and *L. salicola*.

FIG. 2. Developmental changes in total protein in *Lithops karasmontana*.

In contrast with the total protein pattern, the banding pattern for specific enzymes showed no developmental dependence. The band pattern was identical from its earliest detection in young seedlings, through their subsequent development. This is a reflection of the fact that the particular enzymes examined are not those responsible for controlling differentiation in the developing seedling. Indeed, it would be highly fortuitous to find such an enzyme system in a survey such as is described herein.

Comparative Studies

The marked dependence of protein band pattern upon developmental stage prevents using it as a convenient taxonomic character. The results observed when enzyme-specific stains are used are in sharp contrast to the total protein

M: Lithops mennellii
F: L. fulviceps
K: L. karasmontana
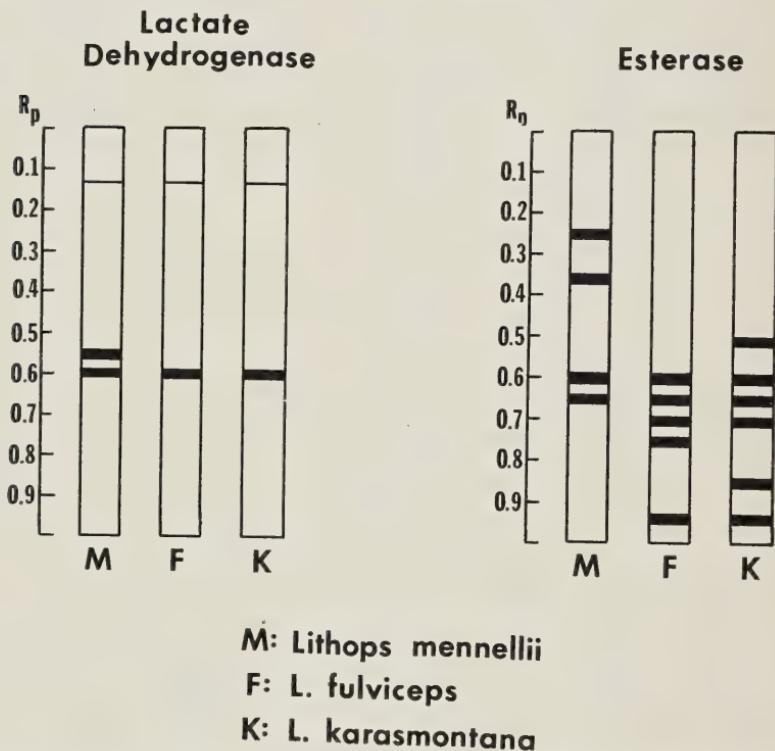
FIG. 3. Lactate dehydrogenase and alpha-esterase isoenzyme patterns of three *Lithops* species.

observations. Species-specific, potentially useful, isoenzyme banding patterns in seedlings are observed as illustrated in Figures 3 and 4. Efforts to stain for enzymes in adult plants were unsuccessful. This is presumably due to the fact that the metabolism of the adult plant is relatively dormant as compared with the actively growing seedling and the enzymes are present only in very small quantities. Polymorphism with respect to isoenzyme pattern has recently been observed in natural populations and cultivars of higher plants (Schwartz and Endo, 1966; Scogin, 1969; Wall, 1968). Such individual variations could not be observed in the present study because of the necessity of pooling numerous seedlings to provide an adequate sample for analysis.

The preliminary systematic conclusions inferred from comparisons of isoenzyme band patterns of several *Lithops* species contradict the currently accepted taxonomic positions of the species based on morphology (*viz.*, *L. mennellii*, *L. fulviceps* and *L. karasmontana*). *L. fulviceps* and *L. mennellii* are placed together in the subgenus Xantholithops (Schwantes, 1951) on the basis of seedling morphology and flower colour, while *L. karasmontana* is placed in the second subgenus *Leucolithops*. Comparison of the LDH and esterase enzyme banding patterns reveal strong similarities (i.e., several bands with identical
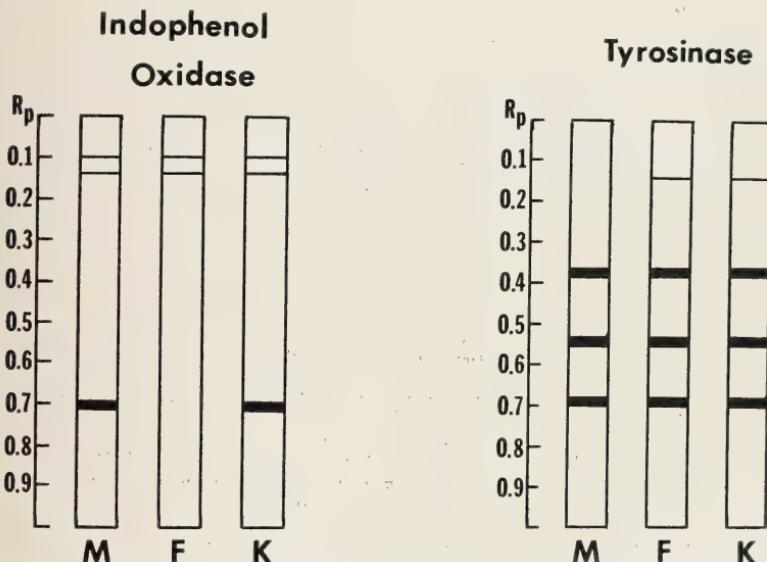
FIG. 4. Indophenol oxidase and tyrosinase isoenzyme patterns of several *Lithops* species. See Fig. 3 for species legend.

electrophoretic mobilities) between the patterns of *L. fulviceps* and *L. karas-montana* suggesting that they are more closely allied to each other than either is to *L. mennellii*. This conclusion is based on the assumption that bands with identical electrophoretic mobilities represent proteins with identical amino acid sequences (or, at least, the same net charge) and are therefore potentially homologous in their evolutionary derivation. These assumptions are not without weaknesses, as has been pointed out by Shaw (1965). An anomolous situation is noted in the indophenol oxidase patterns in that *L. mennellii* and *L. karas-montana* appear the most closely related pair. These results are preliminary and certainly do not form any basis for taxonomic revisions at the present stage, but they do suggest that a more extensive investigation into the utility of the chemical constituents as taxonomic characters in the genus is warranted. This study is being expanded to other species in an effort to detect systematic patterns among the various *Lithops* species and to determine the extent of intra-specific genetic variation as reflected by isoenzyme pattern polymorphism.

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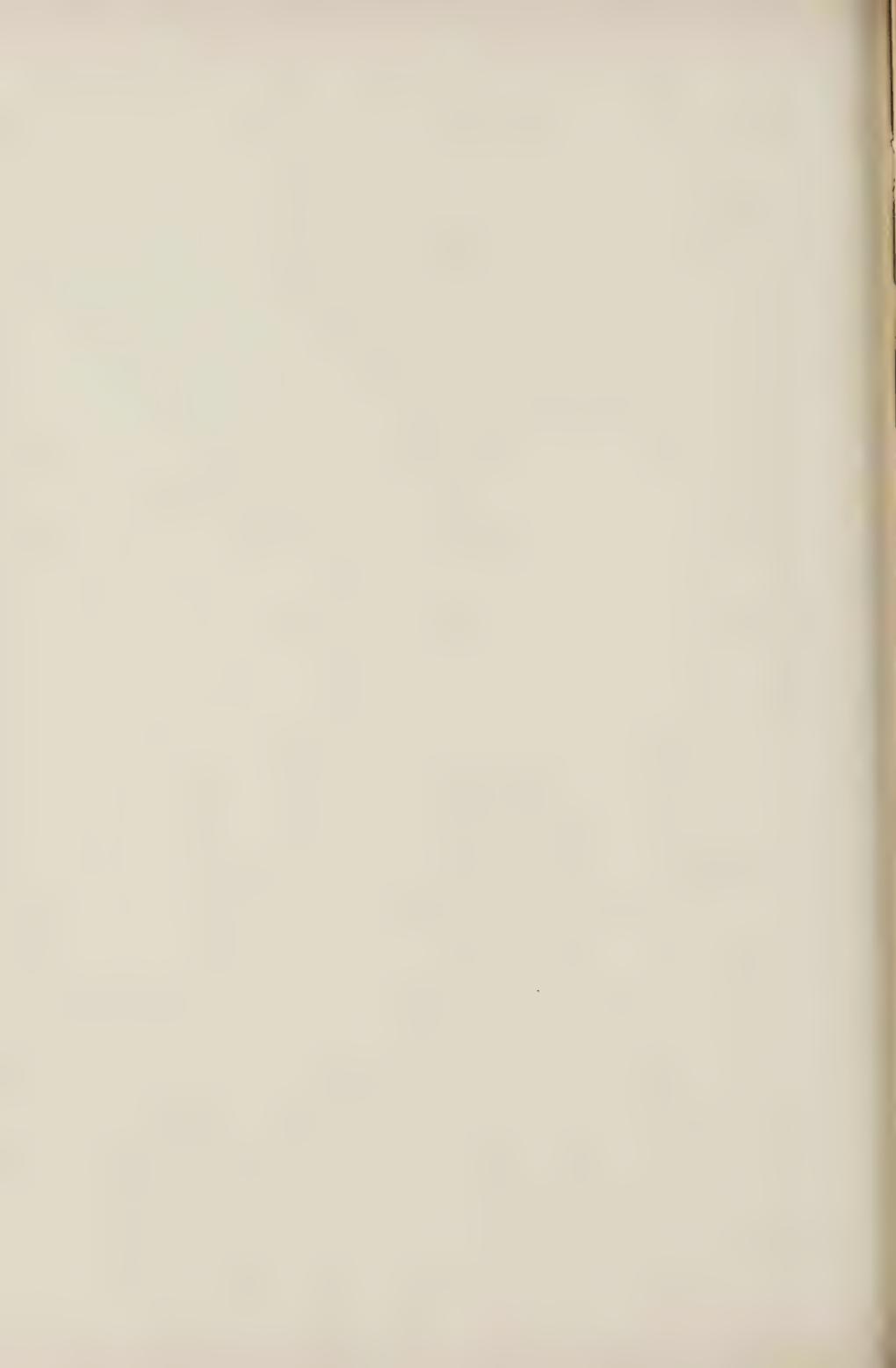
THE VASCULAR CAMBIUM, ITS DEVELOPMENT AND ACTIVITY by W. R. Philipson,
J. M. Ward, and B. G. Butterfield, with pp. 168 text + figures. London:
Chapman & Hall Ltd., New York: Barnes & Noble, 1971. £3.

The vascular cambium has received much attention from investigators, especially during
the last three decades, and the literature on it is scattered. This work is, I believe, the first
comprehensive account, at least in the English botanical literature, on the vascular cambium.
In the book the most important of the accumulated literature on the development, structure,
and activities of the cambium is reviewed and discussed, from the time of De Bary, Hartig,
and Sanio, to the present.

The authors have successfully steered clear of lengthy discussions on the structure of the
wood and bast tissues derived from the cambium, discussing only what is essential in under-
standing the relationships between the activities within the cambium and the resultant deriva-
tive tissues. They also indicate where gaps occur in our knowledge.

The first two chapters deal with the nature, development, and structure, including the
ultrastructure, of the cambium, and the manner of cell division and cell elongation of its
initials and early derivatives. Next, the origin and development of the vascular rays in conifers
and dicotyledons are described, and in what ways the rays of the structurally primitive dicoty-
ledons differ from the more specialised conditions. In the fourth chapter variations in the
size of the fusiform cambial initials are described.

Separate chapters are given to storeyed cambium, to anomalous cambia which are re-
sponsible for the production of the various types of anomalous secondary thickening in
dicotyledons, including work done in South Africa on it, and to the cambium of arborescent
monocotyledons. Another chapter deals with cambium modifications occurring in different
parts of the plant, and a chapter is given to the reactions of the cambium to gravity, which
lead to the formation of reaction wood in inclined and horizontal branches.

Lastly, the factors, both inside and outside the plant, influencing cambial activity are
discussed, as well as experiments conducted to find out the role of the endogenous growth
hormones in activating the cambium.

A good balance has been maintained between text and illustrations. About half of the
almost 30 micrographs are original and most are of satisfactory quality. Numerous line
drawings and diagrams, and several graphs, illustrate certain points in the text clearly.

An extensive bibliography is given with each chapter, showing that the authors have
consulted most of the important literature on the subject, up to and including 1968.

A combined author, subject, and plant name index is given, running to more than twelve
pages.

Printers' or authors' errors are few (Solerader p. 82, 83, diagrammatically for dramati-
cally? p. 87). The meaning of some sentences is unfortunately not quite clear (e.g. farther
from the tree p. 91; sectors with narrowest rings p. 91; successive quarters of the annual rings
p. 127). The use of the term *procambial strands* cannot be approved of for the young, still
undifferentiated, secondary vascular strands formed by the cambium in arborescent mono-
cotyledons.

On the whole, however, the book is well written. It is mainly for the plant anatomist
and wood anatomist, as well as for the postgraduate student, and parts of it are also suitable
for the senior undergraduate student to use as extra reading matter.

M. P. DE VOS

THE ROLE OF NITROGEN IN GRASSLAND PRODUCTIVITY by D. C. Whitehead
with pp. viii + 202, 15 tables and 22 line figures. Commonwealth Agricultural
Bureaux, Farnham Royal, Bucks, England, 1970. £2,25.

It is generally considered that in many countries there is a greater potential for increased
agricultural production from grassland than from arable land provided the grassland is properly
managed. Of the various factors which determine the productivity of a sward, nitrogen plays
a key role. Although numerous investigations have been conducted throughout the world
on various aspects of the nitrogen economy of grasslands, this book is the first attempt to
provide a comprehensive review of the soil, plant, animal and management aspects of the
nitrogen economy of grasslands.

The 160 pages of the text are subdivided into no fewer than 36 chapters which are grouped into three parts, viz: "Nitrogen transformations in grassland ecosystems", "The yield response of grass swards to fertilizer nitrogen" and "Effects of fertilizer nitrogen on the composition and quality of herbage."

The style of the book is that of a highly condensed review rather than a student textbook. With its 516 references and comprehensive index, it will be valued most as a reference source to the wide field it attempts to cover and should find a place on the shelves of all pasture scientists, especially those active in research. Inasmuch as most of the work which has been reviewed was carried out in regions that have a climate and vegetation which is quite different from that of South Africa, the book will probably be less useful to local readers than to those living in the more humid temperate regions of the world although many of the basic principles are universally applicable.

N. GROBBELAAR

EVOLUTIONARY ECOLOGY. ed. by Herbert P. Riley, with pp. xii + 113. Belmont, California: Dickenson Publishing Company Inc., 1970.

This compact book has been prepared to reflect a number of recent trends in evolutionary ecology, or, as it is known by some, genecology. A collection of studies of evolutionary variation is presented, seen in the setting of special environments, population structures and breeding patterns. These are important general topics, touching on a wide range of fields in the biological sciences.

The book includes extracts, and some full texts, of twenty research papers published in the years 1963–1968 by a number of authorities. All the papers chosen are in English and due acknowledgement is made for those that could not be included through limitations of space. The choice was based on showing current trends in work with as wide a variety of organisms and environments as possible. The papers are given in four chapters, entitled "Nature of Variation", "Natural Selection", "Ecological Adaptation" and "Ecological Evolution".

There are brief introductions to each chapter. These are suited more to the specialist reader. The student may need more precise guidance on the trends shown in the range of advanced material that is presented. There are few illustrations, those of the original authors being reduced to a minimum. No new illustrations have been added. With the commendable range of plant and animal problems that are discussed, reference texts should certainly be close at hand when using this book. Full lists of the author's references are given with each paper and extract. Where extracts have been made, the emphasis has been to give the author's discussion and conclusions in full, generally with the introduction and summary.

This editorial policy will certainly be successful in drawing the attention of the specialist and the senior student at South African Universities to the chief material in some key papers. For the student there is some excellent material for seminars, essays and discussions. For the specialist there will be the stimulus for carrying out similar studies in this fundamental field in a South African setting. Indeed, one notes that three of the studies are based partly or wholly on South African plants and animals.

A. V. HALL

INTRODUCTION TO THE FINE STRUCTURE OF PLANT CELLS by M. C. Ledbetter and K. R. Porter, with pp. 188. Berlin, Heidelberg, New York: Springer-Verlag, 1970. $15.40.

This atlas comprises more than 40 large format, full-page (ca. 28×20 cm), and numerous half-page micrographs illustrating the ultrastructure of cell types of higher plants, as studied with the electron microscope.

Meticulous care has been given to the preparation of this work. The micrographs, most of which have not been published before, are of an excellent quality and clarity. They were made mainly in the Laboratory for Cell Biology at Harvard University and also at Brookhaven National Laboratory where the authors work. No one is better suited to publish a work of this kind than these two authors who have published numerous articles on cell fine structure, the senior author during more than two decades, and who, in America at least if not in the rest of the world, stand in the forefront of research on the subject.

In the preface the authors state that they have brought together election micrographs representing a number of cell types from higher plants. This is an understatement, as almost all types of tissues are included. Micrographs are shown not only of the commonly occurring tissues e.g. parenchyma, collenchyma, sclerenchyma, the epidermis and stomata, endodermis, the different kinds of vascular elements, and the vascular cambium, but also of the more unusual cell types with special inclusions, such as a laticifer, a tannin containing cell, an idioblast with developing raphides (are raphidosomes a new discovery?) and secretory cells of a nectary. In fact, the only tissue not illustrated, that I can think of, is periderm.

Special attention is given to the fine structure of cytoplasmic organelles and cell membranes in interphasic and dividing cells, such as chloroplasts, chromoplasts, mitochondria, dictyosomes, microtubules, the endoplasmic reticulum, etc., and to the changes occurring in the cytoplasts of dividing cells.

Micrographs of more than passing interest are three illustrating the differences (and similarities) obtained with different fixing agents. Another, illustrating a freeze-etch image of a cell, is accompanied by a description of the freeze-etch technique which will be intelligible to the layman.

Of interest to the embryologist are the micrographs showing sections through reproductive tissues in higher plants. Parts of the anther in different stages of development are given, e.g. sporogenous tissue, pollen-mother-cells, the spore tetrad, tapetum, and pollen grain, as well as the pollen tube and young female archesporium.

Each plate is accompanied by a description drawing attention to the salient points shown in the micrograph, and also serving to introduce the student, who may not be well versed in cell morphology, to the basic facts concerning cell structure. Some conjectures are made (e.g. sporopollenin in the tracheid wall) and contentious matters raised with regard to the interpretation of certain of the structures seen in the micrographs, and the possible functions of certain of the cell organelles. The authors mention in the preface that this is done intentionally, to provoke thought on the part of the student; they also indicate where our present knowledge is still limited.

As this work is basically an atlas, the descriptions of the micrographs have generally been kept short and to the point. A list of selected references is, however, provided with each description, which will be of inestimable value to the senior student for further study.

Some minor points of criticism can be raised. To my mind it is somewhat of a pity that the more generally accepted terms (e.g. sexine and bacules) for the different layers of the sporoderm of the pollen grain, as advocated by Erdtmann in *The Handbook of Palynology* (1969), have not been used. Also, the description of the very young anther precursor— "a central mass . . . of sporogenous tissue covered by an epidermis"—is misleading.

An alphabetical subject index is lacking, but the table of contents is detailed enough to make up for this omission.

This atlas will be useful and of interest to the undergraduate and postgraduate student alike, as well as to the professional botanist and research worker. It gives the student an excellent insight into the work that has been done on plant cell ultrastructure during the last two or three decades, and also into the problems that have not yet been elucidated.

The authors, the laboratories in which the micrographs were made, as well as the publishers, can be congratulated with this admirable work.

M. P. DE VOS

THE LINNAEAN SPECIES OF *CRASSULA*

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ABSTRACT

Twenty-eight species of *Crassula* as used by Linnaeus are reviewed: three of these do not belong to the genus, one is a European species and twenty-four are South African. Of the latter seven are relegated to synonymy, *C. punctata* is regarded as a nomen confusum, *C. strigosa* and *C. muscosa* must be taken up; *C. tetragona*, *C. subulata*, *C. pruinosa* and *C. perfoliata* are re-interpreted and, as a result, *C. arenicola*, *C. pustulata*, *C. robusta* and *C. perfoliata* var. *miniata* are described.

UITTREKSEL

DIE *CRASSULA* SOORTE DEUR LINNAEUS BENAAM.

Ag-en-twintig *Crassula*-soorte soos gebruik deur Linnaeus word bespreek: drie daarvan behoort nie aan die genus nie, een is 'n Europese soort en vier-en-twintig is Suid-Afrikaanse soorte. Van laasgenoemdes is sewe sinonieme van ander soorte, *C. punctata* is 'n nomen confusum, die name *C. strigosa* en *C. muscosa* moet gebruik word; die interpretasie van *C. tetragona*, *C. subulata*, *C. pruinosa* en *C. perfoliata* is gewysig en as gevolg daarvan is *C. arenicola*, *C. pustulata*, *C. robusta* en *C. perfoliata* var. *miniata* beskryf.

Schonland's (1929) revision of the genus *Crassula* deals in many cases only superficially with the names used by Linnaeus. However, as they are of nomenclatural importance they are re-evaluated and in this paper they are individually discussed as this gives some insight into the methods used at the time.

Linnaeus delimited the genus *Crassula* clearly, partly because his system was based on the number of stamens which happen to separate this genus from most other genera in the family, and partly because of the intercorollary squamae distinguishing it from other genera outside the family. This, however, does not mean that he had a similar concept of the genus as it is accepted nowadays because in subsequent years various species have been justifiably or otherwise referred to other genera, e.g. *C. dichotoma* to *Vauanthes dichotoma* (L.) O. Kuntze. On the other hand the exclusion of *Septas capensis* because of its heptamerous flowers and *Tillaea* with tetramerous flowers is typical of the rigid way in which plants were classified at the time. A *Cotyledon*, "*C. alternifolia*" was included in *Crassula*, probably because it was described from an illustration.

Linnaeus arranged the species according to their similarities and then numbered them. This meant that everytime a new species was included, the numbering had to be changed, but in Systema Naturae (ed. 13) a more versatile

system was adopted. The species still had their numbers as in Species Plantarum (ed. 2), but the numerical sequence was abandoned, so that new species with their serial number could be included next to the species it most closely resembled.

Many of the Linnaean species are based on illustrations in Dillenius' Hortus Elthamensis. These drawings should receive preference in the selection of type specimens contrary to Schonland's (1929) suggestions, as the specimens had not been used in the production of the illustrations. Only in the case of *C. perfoliata* where the similarity between the two is unmistakable, the specimen was selected as the lecto type (cf. Clokie 1964, An Account of the Herbaria of the Department of Botany in the University of Oxford p. 93).

In this paper the taxonomy of all species and their names known to Linnaeus are discussed in alphabetical order. Also, a manuscript by Prof. T. T. Barnard on the Linnaean species of *Crassula* (at present housed in the Bolus Herbarium) is referred to, and the present author is greatly indebted to Professor Barnard for the use of this manuscript. In addition, the loan of specimens from Geneva is gratefully acknowledged, as well as access and working facilities at the Linnaean Herbarium, London. The author also wishes to thank the Curator of the Fielding Herbarium, Oxford, for the photographs of Dillenius' specimens, and Dr. P. Goldblatt for investigating some specimens in overseas herbaria.

1. *C. alternifolia* [Dodart, Mem. Histoire des Plantes ed. 1. 73 (1676)—Herman, Horti academici Lugd.-Batavi 191 (1687)—L., Hort. Cliff. 497 (1737)— J. Burman, Rar. Afr. Pl. 58 t. 24. f. 1 (1738)] *L.,* Sp. Pl., ed. 1. 283 (1753).
     C. alternifolia cannot be a *Crassula* if the specific epithet is applicable.

However, the reference to Herman's (1687) description gives no clear indication of its identity. The illustration in Dodart (1676) clearly shows a species of *Umbilicus.* The further reference to Burman (1738) adds to the confusion as it seems to illustrate *C. pellucida* at first sight, but could also refer to a plant of another genus altogether. The leaves are distinctly alternate, attenuate, serrate and there is a distinct swelling below the petals indicating a calyx tube, an inferior ovary or a capitulum, but none of these characters are found in a species of the *C. pellucida* group. However, Linnaeus must also have felt uncertain about this species, as he did not change the wording in later publications. No specimen can be traced, therefore it cannot be interpreted, but it seems unlikely that it is a species of *Crassula.*

2. *C. caffra* See *C. tetragona.*
3. *C. centauroides* See *C. strigosa.*
4. *C. ciliata* [Boerhaave, Index Plantarum 1: 292 (1720)—Dillenius, Hort. Elth. 116 t. 98 f. 116 (1732)—L., Hort. Cliff., Append. 496 (1737)] *L.,* Sp. Pl. ed. 1. 283 (1753)—Type: Dillenius, Hort. Elth. 116, t. 98, f. 116.

Dillenius' illustration leaves no doubt about the identity of the species concerned and Linnaeus kept his description similar throughout his publications. Linnaeus (1737) includes a reference to Boerhaave (1720), but it its doubtful whether this plant is, in fact, the same, as *C. ciliata* does not have subrotund leaves and also "dentibus albis serratis" hardly refers to a ciliate margin.

5. *C. coccinea* [Breynius, Prodr. Pl. Rar. 3: 30, t. 20, f. 1. (1700)—Commelin., Horti medici Amst. 24 (1706)—L., Hort. Cliff. 116 (1737)] *L.*, Sp. Pl. ed. 1. 282 (1753). Type: sine loc. et leg. in Herbarium Hortus Cliffortianus (BM, holo!).

C. coccinea L. is so characteristic that no difficulty about its interpretation arises. Although it is well illustrated by Commelin (1706) and Breynius (1700) the specimen in the Herbarium Hortus Cliffortianus should receive preference as the type specimen, because Linnaeus marked this species in his own copy of the Species Plantarum ed. 1., meaning that it is represented in that herbarium (cf. notes in LINN). The specimen LINN 400.1 is probably of a later date and it is known that specimens of this species were sent to him several times (cf. Barnard p. 4; Jackson (1918) in Proc. Linn. Soc., Suppl. p. 9.).

6. *C. cultrata* [Dillenius, Hort. Elth. 115, t. 17, f. 114 (1732)] *L.*, Sp.Pl. ed. 1. 283 (1753)—L., Mantissa Altera 361 (1771). Type: Dillenius, Hort. Elth. 115, t. 17, f. 114.

Schonland's (1929) suggestion that the specimen (LINN 400.9) should be taken as the type specimen is not acceptable, as it was deposited in the herbarium much later and "cultrata" added by Linnaeus fil.

7. *C. cymosa Bergius* See *C. subulata* L.

8. *C. dichtoma* [Herman, Horti acad. Lugd.-Batavi 550, t. 553 (1687)]. *L.*, Pl. Rar. Afr. 9 (1760). Type: Herman, Horti acad. Lugd. Batavi t. 553.

The description is remarkably short and seems to have been drawn up from Herman's plate 553 (for discussion see under *C. strigosa*), which is clear and leaves no doubt about the species concerned.

Thunberg (1823) interpreted this species as a "subpetiolate" leafed form of the *C. pellucida*-group in fact, *C. pellucida* itself, according to the specimens in his herbarium. However, Linnaeus fil. interpreted the species both ways, judging by the specimens he identified (LINN 400.12, correct; LINN 400.13, 14, 15 sensu Thunberg).

9. *C. flava* [Burman, Pl. Rar. Afr. 37, t. 23, f. 2. (1738)] *L.*, Mantissa 60 (1767)— Type: Caput Bonae Spei, sine leg. in LINN 400.3 (holo!).

C. flava is based on a specimen (LINN 400.3) inscribed "flava" by Linnaeus which Linnaeus fil. deleted and referred to *C. cymosa*, according to his and Thunberg's interpretation of this species. This specimen is probably the one sent to Linnaeus by Burman in 1764 (Barnard, p. 4).

10. *C. fruticulosa* See *C. tetragona*.

11. *C. glomerata Bergius*, Plantae Capensis 85 (1767)—L., Mantissa 60 (1767)—
    Type: Cape, *Bergius* s.n. (SBT, holo).

    C. scleranthoides Burman f., Fl. Cap. 8 (1768)—Type: Cape, Burman
    Herbarium (G, holo!).

Linnaeus' description is antedated by Bergius' publication by about a month.
Linnaeus' description is unusually detailed and as he mentioned, must have
been drawn up at least partly from a flowering specimen in Hortus Uppsalensis.
However, Linnaeus must also have used the fruiting specimen (LINN 400.16)
probably sent to him by Burman (cf. *C. flava*) and a specimen in a similar stage
of development as the one found in Burman's Herbarium. *C. sclerenthoides*
Burman f. which obviously refers to the same species, is probably based on
the similar specimen in the Burman collection (see Barnard, p. 19). Hence,
Burman's description "floribus ultimis capitatis", and thus refers to a fruiting
specimen. The name *C. scleranthoides* was never written onto the specimen
and only "*C. glomerata*" in N. L. Burman's hand is found on this sheet.

12. *C. imbricata* Burm. f. See *C. muscosa L.*

13. *C. muscosa* L., Pl. Rar. Afr. 10 (1760)—Sp. pl. ed. 2.: 405 (1762)—Mantissa
    altera 361 (1771). Type: Cape, sine leg. in Burman Herbarium (G, holo!).
    C. imbricata Burm. f., Fl. Cap. 8 (1768). Type as for *C. muscosa.*
    C. lycopodioides Lam., Dict. 2: 173 (1786). Type: Africa, Lamarck
    (P–LA, holo).

Schonland placed *C. muscosa* hesitantly under *C. lycopodioides*, but from
the original description of the species it seems that Linnaeus was indeed re-
ferring to this species: "foliis . . . caulem obtengentibus, floribus sessilibus".
Although it might be inferred from "Caules filiformes . . ." underlined by
"caule herbaceo prostrato" added by Linnaeus in 1762, that one of the species,
C. campestris or *C. parvula* was intended. These are excluded by continuing
"Caules . . . rarius ramosi" and "Foliis ovatis, carnosis obtusiusculis, in
exiccatis sub foliorum margine ordo punctorum". The latter referring to the
clearly visible hydathodes. This description must have been drawn up only
from a specimen, and the reference to Herman (1698)—which apparently refers
to *C. campestris*—did not contribute to the preparation of the description. In
fact, Linnaeus (1771) himself excludes the latter reference.

A Burman specimen inscribed apparently by J. Burman "*C. imbricata*",
the name Linnaeus had originally sent to N. Burman (see Barnard, p. 3,5), or
more likely, Linnaeus accepted the name J. Burman had previously written on
the sheet, otherwise Linnaeus would have written the name he had envisaged
first, as he had done with *C. dichotoma* and *C. strigosa*, plants of the same
consignment. However, later Linnaeus seems to have preferred Herman's
epithet "muscosa" and as such it was published.

This Burman specimen shows a few single flowers, a character unusual for that species, yet mentioned by both Linnaeus and N. L. Burman in their respective descriptions. Judging by this, the spreading leaves and unusually exposed internodes, it appears that the specimen belongs to a form occurring in the vicinity of Saldanha Bay and which was later described by Ecklon & Zeyher as *Tetraphyle littoralis*.

This specimen is, therefore, the type specimen of *C. muscosa L.* and *C. imbricata* N. L. Burman, the latter being described without Burman's knowledge of Linnaeus' publication.

14. *C. nudicaulis* [Dillenius, Hort. Elth. 116, t. 98, f. 115 (1732)] *L.*, Sp. Pl. ed. 1: 283 (1753)—Type: Dillenius, Hort. Elth. 116, t. 98, f. 115.
    Dillenius' illustration leaves no doubt as to the species concerned.

15. *C. obvallata L.*, Mantissa 61 (1767).
    This species can clearly be recognised from the description of the peculiar petals and rather broad, slightly oblique leaves. From the description it is clear that Linnaeus used a live specimen, but no specimen has been preserved. However, this species must be relegated to the synonymy of *C. nudicaulis*, a local narrow-leafed form of this widespread species.

16. *C. orbicularis* [Dillenius, Hort. Elth. 119, t. 100, f. 119 (1732)] *L.*, Sp. Pl. ed. 1. 283 (1753)—Fl. Cap. (1760), *orbiculata*. Type: Dillenius, Hort. Elth. 119, t. 100, t. 119.
    Dillenius' figure illustrates the species clearly.

Of the three specimens that Linnaeus fil. identified as *C. orbicularis*, LINN 400.27 and 400.28 are probably the leaf rosette of this species, but an inflorescence of a plant of the section Globulea has been added to specimen 400.27. Specimen 400.29 must be identified as *C. quadrangularis* Schonl.

17. *C. pellucida* [Dillenius, Hort. Elth. 119, t. 100, f. 119 (1732)] *L.*, Sp. Pl. ed. 1. 283 (1753). Type: Dillenius, Hort. Elth. 119, t. 100, f. 119.

Dillenius' figure illustrates the species clearly and Linnaeus never altered or added to the description.

18. *C. perfoliata* [Commelin, Praeludia Botanica 74, f. 23 (1703) – *Dillenius*, Hort, Elth. 114, t. 96, f. 113 (1732)] *L.*, Sp. Pl. ed. 1: 282 (1753)—Miller, Dict. t. 108 (1760). Type: Promontorium Bonae Spei, *Dillenius* s.n. (OXF, lecto, photo!).

Although Linnaeus cites the illustrations of Dillenius and Commelin, the former should receive preference as it bears flowers and is accompanied by a voucher specimen. In more recent publications, the name *C. perfoliata* is generally linked with the red flowered form of this species, but the illustrations of Dillenius and Miller leave no doubt that it was the white flowered variety that was first known in Europe. It was probably brought back from Schrywer's

expedition from the vicinity of the present Aberdeen. These two forms are not only different in their petal colour, but also in the length of the petals. The two plants are never found at the same locality, although the distribution areas would suggest an overlap, and it would appear that the two are ecologically separated.

It is interesting to note that Dillenius calls this plant "Crassula altissima perforata" while Linnaeus quoted him ". . . perfoliata", and hence the epithet.

1. var. *perfoliata*

    C. perfoliata L., Sp. Pl., ed. 1. 282 (1753).

Plant erect up to 1,5 m high, little branched, mainly from the base. *Leaves* lanceolate usually with a broad base abruptly constricted into the upper half, canaliculate. *Flowers* with obtuse petals 3–4 mm long, white to yellowish-green, but stamens and ovary often pink.

Occurring in succulent shrub, usually in mountainous areas from north of Port Elizabeth to Graaff-Reinet and Willowmore.

2. var. **miniata** *Toelken*, var. nov. ab var. *perfoliata* petalis acutis (5-) 6—7 mm longis et miniata.

    C. falcata Wendl., Bot. Beobacht, 44 (1798)—Willd., Enum. 341 (1809)— Sims in Bot. Mag. t. 2035 (1818)—Pole Evans, Fl. Pl. of S. Afr. 1: 12 (1921)—Schonl. in Trans. Roy. Soc. S.A. 17: 225 (1929).

    C. perfoliata sensu Schonl. in Trans. Roy. Soc. S. Afr. 17: 224 (1929), partly.

Plantae erectae, 0,15—1 m altae rare non ramosae. *Folia* lanceolata et canaliculata, vel falcata et plana. *Flores* petalis acutis (5-) 6—7 mm longis, miniati rare rosei.

Type: Cape, Pluto's Vale near Grahamstown, *Tölken* 4280 (BOL, holo).

Occurring on rock outcrops in grassveld or in dry shrub vegetation usually associated with valley bushveld around the lower Sundays and Fish Rivers, but also as far east as Idutywa in the Transkei and odd localities near Steytlerville and Willowmore in the west.

This variety can be divided into two more or less clear groups, namely those plants with falcate leaves which usually grow in rocky outcrops in grassveld and which are known as *C. falcata*; and secondly, the form with lanceolate canaliculate leaves which usually grow in dryer vegetation of the valley bushveld. However, just north of Port Elizabeth a form occurs that exhibits falcate leaves at the base, becoming more and more lanceolate and canaliculate higher up (cf. *Wisura* 152). Even the width of the falcate leaves which is usually double that of the others, becomes unusable as a taxonomic character east of East London, as the leaves of all plants become progressively narrower towards the east. The form with falcate leaves cannot be sufficiently clearly delimited to justify taxonomic rank, nor can the transition near Port Elizabeth be attributed

to a hybrid swarm as the leaf shape is remarkably constant in all the populations investigated.

It seems ill advised to amend the description of *C. falcata* and use it for this variety, as the name has become so entrenched in literature for the form with falcate leaves that is so well known in horticulture.

19. *C. portulacaria* [Dillenius, Hort. Elth. 120, t. 101, f. 120 (1732)—L., Hort. Cliff. 207 (1737)) *L.*, Sp. Pl. ed. 2. 406 (1762). Type: Dillenius, Hort. Elth. 120, t. 101, f. 120.

C. arborea L., Fl. Cap. Amoen. Acad. 5: 365 (1760), *nomen nud.*

Claytonia portulacaria (L.) L., Mantissa Altera 362 (1771).

Linnaeus seemed to be rather uncertain about the identity of this species, from the way it is alternatively omitted and cited in his publications. Finally, in 1771 he transferred it to the genus *Claytonia*. Although Dillenius' figure has no flowers, it can be recognised as illustrating *Portulacaria afra* and not a *Crassula*.

20. *C. pruinosa L.*, Mantissa 60 (1767)—Burm. f., Fl. Cap. 8 (1768).

Type: Caput Bonae Spei, sine leg. in LINN 400.4 (holo!).

The type specimen, LINN 400.4 must be identified as *C. scabra* var. *minor* Schonl., which is common on rocky outcrops in the northern Cape Peninsula. Also, the description gives a strong indication of the plant concerned by "uti tota planta pruinosa crystallina", while the plant from the Bokkeveld, etc. does not show these trichomes so clearly and has very few below the inflorescence and on the calyx.

Thunberg's specimen (UPS 7783) can also be recognised as this species by the dense inflorescence and the shorter petals, but it does not grow in the Karoo, as is stated in his Flora Capensis p. 283.

Therefore, the plant interpreted by Schonland (1929) as *C. pruinosa* is described.

C. pustulata *Tölken*, sp. nov., ab *C. pruinosa* sepalis plerumque glabris rare papillis paucis et petalis 7—8 mm longis differt.

C. pruinosa sensu Harv., Fl. Cap. 2: 346 (1861)—sensu Schonl. in Trans. Roy. Soc. S.A. 17: 222 (1929).

Plantae erectae saepe fastigiatae, (10-) 14—20 cm altae, ramulis multis 1 mm in diametro rare 2—3 mm ad basim, trichomatibus adpressis tengentibus caule et folia; trichomata in internodiis pili recurvati adpressi et in foliis pili adpressi apice basifugo acuto et apice basipetalo bicorni rare mutico. *Folia* lanceolata rare lineares, acuta, 0,5—1,4 cm longa, plerumque 0,2 mm lata fere teretia sed plerumque supra plana, griseo-virides vel griseo-fusca. *Inflorescentia* terminalis plerumque dichasiis duobus, laxa, (1-) 3–8 (-14) floribus. *Sepala* lineo-lanceolatis, acuta, 4—5 mm longa impariter, plerumque glabra rare papillis paucis. *Petala* elliptico-lanceolata, 7—8 (–9) mm longa, saepe appendice

subterminali ut videtur terminali, circiter 3 mm connata, reflexa, denticulata, alba vel pallida flava. *Stamina* 6—7 mm longa antheris atro-bruneis. *Squamae* cuneiformes leviter constrictae ad bases, leviter emarginatae, 0,2 × 0,2—0,3 mm, carnosae, flavae. *Carpellum* gracile, 10—14 ovulis vix tuberculatis.

Type: Cape, Clanwilliam, Pakhuis Pass, *Tölken* 4256 (BOL, holo).

Plants erect often fastigiate, (10–) 14—20 cm high, much branched with wiry branches 1 mm rarely 2—3 mm thick at the base, with lower branches often rooting, with trichomes convering most parts of the plant; trichomes recurved addressed hairs on the internodes, adpressed hairs with an acute apex basifugally and with two lateral points basipetally. *Leaves* linear-lanceolate, acute, 0,5—1,4 cm long, 0,1—0,2 cm broad, almost terete with upper surface usually flat, erect or spreading, grey-green to greyish-brown; sheath 1—1,5 mm long. *Inflorescence* terminal usually with two dichasia, with (1–) 3—8 (–14) flowers in a lax flat-topped cluster. *Sepals* linear-lanceolate drawn into a point, 4—5 mm long uneven, usually glabrous rarely with few small papillae. *Petals* elliptic-lanceolate, often pointed as subterminal appendage appears to be terminal, fused up to 3 mm, reflexed, 8—10 mm long, 2 mm broad, denticulate, white or light yellow. *Stamens* 6—7 mm long with dark brown anthers. *Squamae* wedge-shaped, but only slightly tapering to the base, slightly emarginate, 0,2 × 0,2—0,3 mm, fleshy, yellow. *Carpel* slender with 10—14 ovules hardly tuberculate; style about as long as ovary with red subterminal stigma.

Growing in sandy depressions or in deep pockets of sand on rocks, always associated with sandstone, occurring in the mountainous areas from the Bokkeveld in the south to the Gifberg in the north.

21. *C. punctata L.*, Fl. Cap. 13 (1759), nomen—Syst. Nat. ed. 10, 969 (1759)—
     Sp. Pl. ed. 2: 406 (1762)—non sensu Miller, Dict. (1768).

It is unlikely that this species is synonymous with *C. ramuliflora* as Schonland suggested, as the area in which it grows became known botanically much later. Also, *C. ramuliflora* is usually covered with hairs and the upper and lower leaves on the stem are not distinctly different as Linnaeus (1762) described. This, and the recurved petals mentioned, indicate *C. corymbulosa* as this species fits the description in all respects and could have been introduced into European gardens by Schrywer from his expedition to Graaff-Reinet. According to Linnaeus, this species is based on a Burman specimen and, until this is found, no certainty of the true identity can be ascertained from the description alone.

C. punctata sensu Miller (1768) refers to *C. perforata* because of their flaccid stems and cordate leaves, unlike *C. rupestris* as Schonland suggests.

22. *C. rubens* (*L.*) *L.*, Syst. Nat. ed. 10: 969 (1759).
     Sedum rubens L., Sp. Pl. ed. 1: 432 (1753)—Sp. Pl. ed 2: 619 (1764).
     A European species of Sedum.

23. **C. scabra** [Martyn, Hist. Plant. 24, t. 24 (1728)—Dillenius, Hort. Elth. 117 (1732)] *L.*, Sp. Pl. ed. 1: 283 (1753).

   Type: Dillenius, Hort. Elth. 117, t. 99, f. 117.

   C. scabra is well illustrated by Martyn (1728) and Dillenius (1732), but Schonland (1929) designated the Dillenius specimen as the type specimen. This cannot be accepted as the specimen could not have been used for the plate, as mentioned earlier (cf. Clokie, 1964). However, Dillenius' plate should receive preference because, judging from the length of the petals, the Martyn specimen could have been a hybrid found commonly on the northern slopes of Table Mountain.

24. **C. sclerenthoides** Burm. f. See *C. glomerata L.*

25. **C. strigosa** *L.*, Pl. Rar. Afr. 10 (1760)—Type: Caput Bonae Spei, in Burman Herbarium (G, holo!).

   C. centauroides L., Pl. Rar. Afr. 9 (1760)—Sp. Pl. ed. 2, 454 (1762)—Amoen. Acad. 6: 85 (1763). Type: Caput Bonae Spei, in Burman Herbarium (G, holo!).

   C. sylvatica Licht. ex Schultes 6: 726 (1820)—Type: unknown.

   Although Linnaeus does not specifically state it, it can be inferred from letters that *C. strigosa* is based on a Burman specimen (Barnard, p. 2, 3). In fact, the specimen in the Burman Herbarium has "Crassula strigosa" apparently in Linnaeus' handwriting on it. This must be the type specimen, as it agrees in all respects with the original description. *C. sylvatica* is thus synonymous with *C. strigosa*, as Schonland tentatively indicated.

   Linnaeus (1760) described four new species of Crassulas (*C. strigosa*, *C. dichotoma*, *C. centauroides*, *C. muscosa*) which were probably based on Burman specimens, although this is not stated clearly in this publication (see Barnard, p. 2, 3). In the Burman collection (G) there are two specimens inscribed with what seems to be Linnaeus' handwriting, namely "Crassula strigosa" and "Crassula dichotoma", however, they belong to the same species. The specimen with "Crassula strigosa" is the type of that species. The description of *C. dichotoma* is remarkably short and does not agree with the abovementioned second specimen. This latter specimen agrees with the description of *C. centauroides* in the following points: (1) "Caulis superne dichtome corymbosus"; (2) "ex axilis flores pedunculati, ramis breviores"; (3) he does not state the habit of the plant which is not distinct from the specimen, but described the distinctly erect habit of *C. dichotoma*. Particularly as the latter description is not separated by its own number from *C. centauroides* in both the original the thesis (1760) and in Amoenitates Academicae 6 (1763), it is unlikely to be merely a printing error.

   Therefore, the author suggests that Linnaeus became uncertain when describing this species, because the specimen which he inscribed "*Crassula*

dichotoma" did not show this type of branching on the whole plant. The short diagnostic description in comparison with those of other species in this publication and the narrow leaves mentioned, seems to indicate that this description was drawn up from Herman's illustration (1687). Yet, in the case of *C. centauroides*, the reference to Herman (1698) seems to have contributed nothing towards the description. In fact, Herman appears to refer to the same species in both these publications, whereas Linnaeus states that the two species can be distinguished by *C. centauroides* having broader leaves and smaller flowers. This is true if the specimen is compared with the illustration as mentioned above.

Having accepted that the specimen inscribed "Crassula dichotoma" is the type of *C. centauroides*, the description of the leaves as amplexicaul, sessile, smooth in *C. centauroides* may be found questionable when one thinks of the species involved. Yet, on superficial investigation, the leaves of the Burman specimen might well seem to be sessile and amplexicaul, because the petioles are adpressed to the stems due to the way the specimen was dried. In addition, the lower leaves are almost glabrous so that the unusual description of the leaves adds proof to this interpretation.

According to the above interpretation *C. centauroides* is thus synonymous with *C. strigosa* L., as J. Burman had correctly recognised, and had written "strigosa" over Linnaeus' inscription "Crassula dichotoma".

Throughout his subsequent publications, Linnaeus treated the two as separate species and did not change the description. In the Mantissa Altera (1771), however, a description of vegetative parts of *C. centauroides* is added. It is not clear to which plant he is referring, but it certainly does not fit the species as interpreted above, nor to a species of the *C. pellucida*-group as Thunberg, Linnaeus fil. and subsequent workers have interpreted this species. The phrase (Linnaeus 1771) "Folia . . . carnosa, supra punctatis excavatis", obviously refers to hydathodes, and cannot apply to any of the herbaceous Crassulas, as Linnaeus clearly stated in his original description. Could Linnaeus have returned the specimens to Burman before he compared the plants, when he was drawing up his second description?

26. *C. subulata* [Herman, Horti acad. Lugd.—Batavi 550, t. 552 (1687)] *L.*, Syst. Nat. ed. 10, 969 (1759)—Sp. Pl. ed. 2, 404 (1762)—Mantissa Altera 360 (1771)—non sensu Bergius, Fl. Cap. 83 (1767)—Type: Herman, Horti acad. Lugd.—Batavi t. 552.

    C. cymosa Bergius, Pl. Cap. 84 (1767)—L., Mantissa Altera 122 (1771). Type: Cape, *Bergius* (SBT, holo).

    C. ramosa Thunb. in Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 330 (1778)—Prodr. 55 (1794)—Fl. Cap. ed. Schultes 284 (1823)—Type: Cape, Swartkops River, *Thunberg* in UPS 7788 (microfiche).

The diagnosis of *C. subulata* L. (1759) and (1762) fits the illustration of Herman (1687) and it was probably drawn up from this figure as Linnaeus seems to have produced rather short descriptions when no specimen of the plant was available (cf. *C. dichotoma*). Linnaeus (1762), in fact, expresses his uncertainty about this species, yet keeps the diagnosis unaltered throughout subsequent works, except in Matissa Altera he adds to it under observations. This first reference added, Pet. gaz. t. 89, f. 8. at first glance appears to be similar, but it clearly shows broad reflexed petals unlike Herman's illustration (1687) and seems to be a poor drawing of *C. cymosa* sensu Schonland (1929) or *C. flava* L. However, it is difficult to identify it with certainty. The second one, Bergius Pl. Cap. 83, he himself adds the reservations that it has red flowers, but continues with a description, some phrases of which were directly taken from Bergius' description. Bergius was referring to *Rochea odoratissima* DC. in which the flowers often turn red when they become older. Linnaeus even identified a specimen of *R. odoratissima* (LINN 400.21) as *C. subulata*. This interpretation was followed by many subsequent workers.

C. cymosa Bergius is synonymous with *C. subulata* L. ("Folia linearia, untrinque glabra acutiuscula . . . Corolla . . . laciniis linearilanceolatis acutius-culus . . ."), but Linnaeus follows Bergius incorrectly in so far that he accepts Bergius' interpretation and even uses some of his phrases when he described *C. cymosa* in Mantissa Altera. *C. cymosa* sensu Thunb. refers to *C. flava* L. (*Thunberg* in UPS 7749). *C. cymosa* sensu Schonl., and many other authors, has been so well established under this epithet that no later synonyms can be found and consequently it is described here as *C. arenicola*.

C. ramosa Thunb. must also be referred to the synonymy of *C. subulata* and although it is a rather stout specimen (*Thunberg* in UPS 7788) it shows the pointed leaves, very dense inflorescence and the typically pointed petals.

C. arenicola *Toelken*, sp. nov., ab *C. subulata* foliis planis in basibus plan-tarum muticis ciliis expansis, petalis ellipticis obtusis.

C. cymosa sensu Schonl. in Trans. Roy. Soc. S. Afr. 17: 216 (1929).

Plantae usque ad 35 cm altas, multis ramis ad basim, ramis majoribus decumbentibus et inflorescentis erectis. *Folia* lineari-elliptica, vix contracta ad basim et apicem, plerumque mutica, (1–) 2—3 (–4) cm longa, 0,2—0,4 cm lata, erecta, plana, glabra, ciliis marginalibus expansis rare recurvis, virides vel flavovirentes. *Inflorescentia* terminalis, ramosa dichasiis pluris floribus multis; pedunculus 15—25 cm longa. *Sepala* lanceolata, mutica, inaequales 1,5—2,5 mm longa, glabra, virides. *Petala* elliptica, obtusa, 3—4 mm longa, reflexa, c. 1 mm connata, pallide flava vel eburnea. *Stamina* 2—3 mm longa antheris atrobruneis. *Squamae* oblongae vix contracta ad medium, 0,7—0,8 × 0,4—0,5 mm, pallide flava. *Carpellum* ovario gracili 10—12 ovulis, stylo circiter dimidio longo quam ovario, stigmate terminali.

Type: Cape, Clanwilliam, Pakhuis Pass, *Tölken* 4255 (BOL, holo).

Plants up to 35 cm high, much branched at the base, with main branches decumbent and erect inflorescences. *Leaves* elliptic-linear to strap-like, slightly tapering to both ends and usually with a blunt apex, (1–) 2—3 cm long, 0,2—0,4 cm broad, erect, flat, glabrous with marginal cilia which are usually erect rarely slightly recurved and with a swollen apex, green to yellowish-green; sheath 1—2 cm long. *Inflorescence* terminal, branching with several dischasia with many flowers; peduncle 15—25 cm long. *Sepals* lanceolate with blunt apex, 1,5—2,5 mm long unequal, usually glabrous, green. *Petals* elliptic, obtuse or with blunt apex, 3—4 mm long, reflexed, c. 1 mm fused, light yellow or cream. *Stamens* 2—3 mm long with dark brown anthers. *Squamae* oblong, slightly constricted in the middle, 0,7—0,8 × 0,4—0,5 mm, light yellow. *Carpel* with slender ovary with 10—12 ovules, with style about half as long as ovary and with terminal stigma.

Growing on sandy slopes but usually in shallow sand and usually in open vegetation on the Cape Flats and the adjoining mountain slopes from the Cape Peninsula to the Gifberg extending to Hondeklip Bay along the coast.

27. *C. tetragona* [Boerhaave, Index Plant. 1: 292 (1720)—L., Hort. Cliff. 116 (1737)] *L.*, Sp. Pl. ed. 1. 283 (1753)—Sp. Pl. ed. 2. 404 (1762)—Mantissa Altera 361 (1771). Type: Caput Bonae Spei, sine leg. in LINN 400.6 (holo!).

C. *fruticulosa* L., Mantissa 61 (1767).

Type: unknown.

C. *caffra* L., Mantissa Altera 222 (1771).

Type: unknown.

C. *acutifolia* Lam., Dict. 2: 175 (1786).

Type: Africa, *Lamarck* (P–LA, holo).

Linnaeus' (1753) description of *C. tetragona* does not give an indication of whether he was dealing with *C. tetragona* or *C. acutifolia* in the way Schonland (1929) interpreted these species. He refers, however, to his earlier work in Hortus Cliffortianus (1737) where he had given a more detailed description, partly that of van Royen's. The only indication that he is referring to *C. tetragona* sensu Schonl. in reflected in the height of the plant being given as 1—3 ft, whereas *C. acutifolia* rarely grows higher than 1 ft. On the other hand the description indicates reference to *C. acutifolia* in the following ways. Firstly, "folia . . . carnosa patentia" indicates leaves unlike those of *C. tetragona* sensu Schonl. as they are usually bent upwards, a point mentioned by Linnaeus (1762), and therefore the above citation is unlikely to refer to this species. Secondly, the inflorescence is described as an "umbella" probably referring to the flat-topped thyrse found in *C. acutifolia*, whereas the inflorescence of *C. tetragona* sensu Schonl. is much branched and irregular. From this it appears

that both species were known to Linnaeus. As the height of the plant is given as 1—3 ft it seems that Linnaeus regarded both plants as one species, but the description was drawn up predominantly from a specimen of *C. acutifolia*. The specimen (LINN 400.6) must have been incorporated in the herbarium before 1748 as "Crassula" is written at the top of the sheet together with "tetragona" in Linnaeus' hand leaves no doubt that this specimen must be accepted as the type (Savage 1945, Catalogue of the Linnaean Herbarium). The additional information Linnaeus added in 1762 seem to be derived from Bradley's, Hist. Pl. Succ. 5: 18, t. 11, fig. 41 (1732), which illustrates typical *C. robusta*.

Later, however, Linnaeus realised that the two plants were different when he described *C. fruticulosa*. He specifically stated that they were similar in habit, but *C. fruticulosa* was distinguishable from *C. tetragona* as it grew up to 1 ft, whereas the latter grew 3—4 ft high. Unfortunately, this description was drawn up only from vegetative material, so that one cannot be absolutely certain that Linnaeus was not referring to yet another species, particularly as there is no specimen preserved.

Then in 1771 Linnaeus described *C. caffra* which cannot be distinguished from *C. fruticulosa* in vegetative characters and, in fact, the description could have been drawn up from a specimen of *C. tetragona* mentioned earlier. However, he did not mention in what way *C. caffra* differed from *C. fruticulosa* or *C. tetragona*.

In the same publication, under observations, Linnaeus mentioned how easily plants of *C. tetragona* produce adventitious roots when kept dry, a character mainly found in *C. tetragona* sensu Schonl. and to a much lesser degree in *C. acutifolia*. Later Linnaeus seems to have clearly distinguished the larger plant as *C. tetragona* and he also referred to the clear illustration of Bradley's (1732).

C. tetragona must either be rejected as a nomen confusum, or, as it is accepted here, must be interpreted according to the perfectly clear type specimen, which belongs to the same species as *C. acutifolia*. *C. tetragona* thus supersedes *C. acutifolia* Lam. The only later name for the more robust species is *C. decussata* Salisb. which is a nomen nudum, and therefore *C. robusta* is described.

C. robusta *Tölken*, sp. nov, ab *C. tetragona* habitu robusto plantis 30—80 cm altis, caulibus carnosis (0,2–) 0,3—1,5 cm in diametro cortice confringenti et caduco et foliis (0,4–) 0,5—0,7 cm latis ad bases differt.

Plantae erectae (3)– 40—80 cm altae, glabrae, ramosae, ramis carnosis (0,2) 0,3—1,5 cm in diametro, cortice confringenti et caduco. *Folia* lanceolata, subulata, (1,5–) 2—3 (–4) cm longa, (0,4–) 0,5—0,7 cm lata, fere teretia sed supra et inferiora aliquantum complanata, apice flexo basifuge. *Inflorescentia* terminalis, thyrsiformis, ramis pluribus et floribus multis, ut videtur pileata;

pedunculus 2—5 cm longus. *Sepala* laneolata, mutica, 0,5—1 mm longa, glabra, virides. *Petala* elliptico-lanceolata, 1,5—2 mm longa, recurva vel reflexa sed erecta fructu, c. 0,5 mm connata, alba vel eburnea. *Stamina* 2—2,5 mm longa antheris atrobruneis. *Squamae* transverse anguste rectangulares, leviter constrictae ad bases, emarginatae, 0,3 × 0,6—0,7 mm, carnosae, pallide flavae vel albae. *Carpellum* ovario 8 (–10) ovulis vix tuberculatis.

Type: Cape, Pluto's Vale near Grahamstown, *Tölken* 4281 (BOL, holo).

Plants erect (30–) 40—80 cm high, glabrous, branched, with fleshy branches (0,2–) 0,3—1,5 cm in diameter with flaking bark on the older stems. *Leaves* lanceolate, subulate, (1,5–) 2—3 (–4) cm long, 0,5—0,7 cm broad, almost terete with the upper and the lower surface only slightly flattened, arched upwards, glabrous, green sometimes yellowish-green; sheath rarely longer than 1 mm. *Inflorescence* terminal, thyrsoid, with many branches and numerous flowers and often with many bracts along the branchlets; peduncle 2—5 cm long. *Sepals* lanceolate with blunt apex, 0,5—1 mm long, glabrous, green. *Petals* elliptic-lanceolate, 1,5—2 cm long, recurved or reflexed but erect when fruiting, c. 0,5 mm fused, white or cream. *Stamens* 2—2,5 mm long with dark brown anthers. *Squamae* a transversely compressed rectangle very slightly constricted towards the base, 0,3 × 0,6—0,7 mm, light yellow or white. *Carpel* with ovary having 8 (–10) ovules, with style c. 1 mm long and terminal stigma.

Growing in sheltered valleys or between other plants, but rarely in the shade, in dry shrub vegetation mainly associated with the Fish—, Sundays—and Groot River valleys in the Eastern Cape.

28. *C. verticillaris L.*, Mantissa Altera 361 (1771).

This seems to be an European species that will require a complex evaluation because no specimen has been preserved. However, the complex does not involve either *C. campestris* or *C. zeyheriana* as might be apparent from the description. The two specimens of the former (LINN 400.19, 20) could not have been used for the description of *C. verticillaris*, as neither of them is much branched. *C. zeyheriana* Schonl. was brought to Europe by Thunberg and, in fact, *C. debilis* Thunb., Fl. Cap. ed. Schultes 280 (1823) must be taken up. An unmistakable type specimen is to be found in the Burman Herbarium (G!).

THE EFFECT OF AGE AND LEAF POSITION ON CARBON DIOXIDE COMPENSATION POINT (Γ), AND POTENTIAL PHOTOSYNTHETIC CAPACITY, PHOTORESPIRATION AND NITRATE ASSIMILATION IN *HORDEUM VULGARE L.*

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Abstract

The carbon dioxide compensation point (Γ) was found to vary with age under constant environmental conditions. The activities of ribulose 1–5, diphosphate carboxylase, glycollate oxidase, and nitrate reductase were found to increase with ascending leaf position. The activities were also found to fluctuate generally decreasing with age.

The use of these enzyme activities are considered as possible indicators of carbon dioxide fixation, and output during photosynthesis and the possible relationship between nitrogen metabolism and photorespiration is discussed.

Uittreksel

DIE UITWERKING VAN OUDERDOM EN BLAARPOSISIE OP KOOLSUUR-GASKOMPENSASIEPUNT (Γ) EN POTENTIËLE FOTOSINTESIESE KAPASITEIT, FOTORESPIRASIE EN NITRAAT ASSIMILASIE IN *HORDEUM VULGARE L.*
Dit is gevind dat, onder konstante omgewingstoestande, die koolsuurgaskompensasiepunt met ouderdom varieer. Die aktiwiteite van ribulose difosfaat karboksilase, glikolaat oksidase en nitraat reduktase neem toe met stygende blaarposisie. Dit is ook gevind dat die aktiwiteite 'n skommeling toon, met 'n algemene afname namate die blaar ouer word.

Hierdie ensiemaktiwiteite kan moontlik as indikators van koolsuurgasfiksering en -produksie tydens fotosintese gebruik word. Die moontlike verwantskap tussen stikstofmetabolisme en fotorespirasie word bespreek.

Introduction

Recent evidence has strongly supported the concept of photorespiration occurring in green plant tissue (Ludwig and Canvin, 1971; Zelitch, 1968; Tregunna, Krotkov and Nelson, 1966; Forrester, Krotkov and Nelson, 1966). It is thought that this process is associated with single membrane microbodies termed peroxisomes (Tolbert and Yamazaki, 1969). Tolbert (1971) has recently suggested the enzymes associated with peroxisomal metabolism. Further it is generally accepted that photorespiration influences the carbon dioxide compensation point (Γ) (Jackson and Volk, 1970).

The process of photorespiration is markedly influenced by the oxygen concentration, the process being stimulated by increasing oxygen levels. Thus, the carbon dioxide compensation point (Γ) is also affected by the oxygen concentration in the environment (Forrester *et al, loc. cit.*). Suggested schemes for the influence of oxygen on photorespiration have been put forward by Ogren and Bowes (1971) and Plaut and Gibbs (1970).

It has been generally accepted that the Γ of a leaf under constant environmental conditions is stable, however, the work presented in the paper suggests that this may not be the case. In an attempt to study this further, the level of carbon dioxide uptake (photosynthesis) and output (photo-respiration) was studied, by observing the enzyme activities associated with these two processes together with the Γ. The activity of the enzyme ribulose 1—5, diphosphate carboxylase (4.1.1.f.) was used to assess the level of carbon dioxide uptake, as it is accepted as the main photosynthetic carboxylating enzyme in Calvin Cycle (C3) plants. The selection of marker enzymes for the decarboxylation process was more complex. Glycollate oxidase (1.1.3.1.) is thought to be one of the main terminal oxidases associated with photorespiration (Tolbert and Yamazaki, 1969) however, the measurement of its activity need not necessarily give a measure of the level of decarbolyation due to the glyoxylate—glycollate shunt brought about by another peroxisomal enzyme NADP* glyoxylate reductase (1.1.1.26) (Tolbert and Yamazaki, *loc. cit.*) or alternatively the formation of glycine from glyoxylate and its subsequent removal from the peroxisome in this form. In the scheme suggested by Tolbert for peroxisomal metabolism, associated with photorespiration, glutamic acid plays a major role. Further as glutamic acid is considered to be the prime product of reductive amination, it was decided to investigate the possibility of using the enzyme nitrate reductase (1.6.6.2) as a measure of peroxisomal activity in plants grown with nitrate as the sole nitrogen source.

MATERIAL AND METHODS

Barley plants, *Hordeum vulgare L.* (Sunblest Seed, Desert Seed Co., El Centro, U.S.A.) were grown in soil in 10 cm diameter pots supplemented daily with Long Ashton nutrient medium (Hewitt, 1952) under constant environmental conditions of 14 hours of light at 27°C and 10 hours of dark at 22°C. During the first days the plants were thinned to leave only plants of equal height. Two growth chambers were used with a staggered light regime, so that sampling could be made twice a day, after the plants had only received 4 hours of light. Twenty four hours prior to sampling, the plants were supplied with 100 mls nitrate solution containing 500 p.p.m. nitrate.

Sampling commenced after the first leaf (Leaf 1) was longer than 12 cms. This leaf was only fully expanded four days after the initial sample. The same procedure was followed for leaves 2, 3 and 4. Leaf 4 being the uppermost leaf to appear on the axis.

Sixteen similar leaves in age and leaf position were used for each set of determinations, eight of which were used to determine the Γ, and the remainder for enzyme activity.

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*Nicotinamide adenine dinucleotide phosphate.

Determination of carbon dioxide compensation point: Eight freshly sampled leaves were placed with their cut ends in a 10 ml beaker containing deionised water. The water surface was coated with wax to prevent the buffering effect of the water on the carbon dioxide. The leaves were then placed in a sealed glass chamber with a constant light source of 20 000 lux, and the temperature maintained at 30°C. The carbon dioxide compensation point was measured using a Hartmann and Braun I.R.G.A. in a closed system. Oxygen was also measured using a Hartmann and Braun paramagnetic oxygen analyser. The oxygen level remained constant at 21 per cent throughout the experiment.

Enzyme extract: 500 mg of freshly cut leaf material was ground in 10 ml of cold grinding media, using a chilled mortar and pestle with acid washed sand. The grinding medium was a modified Breidenbach, Kahn and Beevers (1968) medium containing 0,15 M Tris-HCl buffer (pH 7,5), 0,01 M EDTA (pH 715), 0,01 M KCl, 0,001 M $MgCl_2$, and 10 mM Dithiotreitol. The extract was squeezed through cheese-cloth, and centrifuged at 1 000 g for 5 minutes. The supernatant was used as a crude enzyme source. All the above procedures were carried out at 0°C.

Assay of ribulose 1—5, *diphosphate carboxylase* (4.1.1.f): A modified Bjork-man (1968) method was employed, measuring the incorporation of sodium carbonate C-14 as a measure of enzyme activity. 0,05 ml of enzyme extract was incubated at 25°C for four minutes in the presence of 20,0 μmoles $NaH^{11}CO_3$ (0,5 μCi: μmole^{-1}), 0,2 μmoles ribulose 1—5, diphosphate (Sigma Chemical Co.), 30,0 μmoles Tris-HCl buffer (pH 8,0), 3,0 μmoles $MgCl_2$, and 0,1 μmole EDTA. The reaction was carried out directly in the glass scintillation vial, in a total volume of 0,45 ml. The reaction was stopped, and the excess bi-carbonate removed by the addition of 0,2 ml of 6,0 N acetic acid. The solution was evapo-rated to dryness using a dry air stream for 30 minutes. 0,1 ml of deionised water was added to redissolve the residue. 15,0 ml scintillation fluid (Lips and Beevers, 1966a, 1966b) was finally added, and the number of disintegrations per minute counted on a Packard Tri-Carb Scintillation Spectrometer. A blank without enzyme, and a control in the absence of ribulose 1—5, diphosphate were carried out with each determination.

Assay of glycollate oxidase (1.1.3.1): The assay was a modification of McNaughton and Fullem (1970) method. 0,3 ml of extract was incubated at 25°C in a 0,067 M. Phosphate buffer (pH 7,0) with 10,0 μmoles sodium glycollate (B.D.H.). The total volume was 3,0 ml. The rate of oxygen uptake was measured by a Clarke Polarographic oxygen electrode. The buffer with or without glycol-late was allowed to equilabrate with atmospheric oxygen for three minutes prior to being sealed by the monitoring oxygen electrode. The reaction was initiated by the injection of the enzyme extract. The reaction was followed

for five minutes, and the activity expressed as nett percentage oxygen taken up per minute, the dissolved oxygen content being taken as 100 per cent.

Assay of Nitrate Reductase: The method of Hewitt and Nicholas (1964) was employed.

Protein determination: The soluble protein was estimated colormetrically by the Folin-Ciolcalteau reagent, by the method of Lowry, Rosebrough, Farr and Randall (1951).

All enzymatic activities have been expressed per gram fresh weight. The method was similar to that of Downton and Slatyer (1971). Grinding was tested for its variability against protein and the standard deviation for 20 grinds was less than 1%.

RESULTS

The effect of age on Γ, ribulose 1—5, diphosphate carboxylase, glycollate oxidase, and nitrate reductase activities for leaves 1, 2, 3 and 4, are presented in Figures 1—4.

Carbon dioxide compensation point (Γ). The effect of leaf age on Γ is shown in Graph 'b' of Figures 1—4. The compensation point was observed not to be at a constant level of carbon dioxide, but rather fluctuated with respect to time. In leaves 1, 3 and 4 the initial compensation point was at a higher carbon dioxide level, than at later stages of leaf development. A possible reason for leaf 2 not showing this high initial level was that it was more mature ($\pm$ 15 cms) than the other leaves when it was first sampled. The pattern of Γ variation for the four different leaves, was found to vary and did not give a common pattern.

The average Γ for each leaf is found to be approximately the same for all the leaves and does not decrease with age. This is of particular interest when compared to the enzyme activities.

Ribulose 1—5, *diphosphate carboxylase* (4.1.1.f) *activity:* The effect of age and leaf position on the activity of this enzyme is presented in Graph 'a' Figure 5. The activity is found to increase with leaf position of the main axis, and decreases with leaf age. Activity was observed to fluctuate rhythmically on a frequency common to all leaves, but the amplitude of the fluctuation increases with leaf number.

There appears to be no correlation between the Γ and ribulose 1—5, diphosphate carboxylase activity observed.

Glycollate oxidase (1.1.3.1) *activity:* The influence of leaf age and position on the activity of this enzyme is presented in Graph 'c' Figure 5. Like ribulose 1—5, diphosphate carboxylase the activity is found to increase with leaf position up the main axis, and to decrease with ageing of the leaf. The activity does fluctuate with age, but does not follow the regularity observed with the carboxylating enzyme. Again no correlation could be obtained between the observed activity of this enzyme, and the Γ measured.

Nitrate reductase (1.6.6.2) *activity:* The effect of leaf age and position on the activity of this enzyme is presented in Graph 'b' Figure 5. Like the previous two enzymes, nitrate reductase activity is observed to increase with leaf position up the main axis, and the activity fluctuates as it ages, with no regular pattern, but with a decrease in activity as ageing occurs. Also no direct correlation between nitrate reductase activity and Γ was found.

Ratio of Glycollate oxidase activity to ribulose 1—5, *diphosphate carboxylase:* It was argued that if ribulose 1—5, diphosphate carboxylase activity was directly related to carbon dioxide fixation, and glycollic acid oxidase activity was a measure of photorespiration, then the ratio of these two activities should be related to the measured Γ. The ratio of the two enzyme activities are plotted for each leaf in Graph 'c' of Figures 1—4. When the plots of the ratio of these two enzyme activities are compared with the measured Γ, a weak correlation is obtained. The points which do not correlate have been indicated on Graph 'c' of Figures 1—4.

Ratio of nitrate reductase activity to ribulose 1—5, *diphosphate carboxylase activity:* If nitrate reductase activity is used as an indirect indicator of photorespiration using the reasoning given in the introduction, and the ratio of this enzyme activity to ribulose 1—5, diphosphate carboxylase activity is plotted, the results are presented in Graph 'a' Figures 1—4. When the ratio of these two enzymes activity is compared with the observed Γ, a reasonably good correlation was obtained.

The percentage correlation of the calculated ratios of Glycollate oxidase activity/ribulose 1—5, diphosphate carboxylase activity to Γ, and nitrate reductase activity/ribulose 1—5, diphosphate carboxylase activity to Γ, are presented in Table 1. These results show the improved correlation obtained when nitrate reductase activity was used as an indirect indication of photorespiration.

DISCUSSION

The results indicate that the carbon dioxide compensation point Γ, under constant environmental conditions varies with the age of the leaf and the position of the leaf on the main axis. This variation in Γ suggests that the equilibrium of carbon dioxide uptake and output is probably in a continual state of flux.

The fluctuation of the Γ cannot be explained by the observed ribulose 1—5, diphosphate carboxylase activity in Graph 'a' Figure 5. The activity of this enzyme shows a rhythmic fluctuation, which is not observed in the measured Γ. The rhythmic pattern observed for the carboxylating enzyme, which had a frequency common to all the leaves investigated, may correspond to periods of high and low demand for carbon skeletons, respectively during the growth of the plant. In addition, the pattern of ribulose 1—5, diphosphate carboxylase

TABLE 1

The percentage positive correlation of the with the calculated ratios of the four leaves sampled.

(*a*) The %-age correlation of the glycollate oxidase: ribulose 1–5, diphosphate carboxylase ratio

 (i) on a relative basis

(ii) on a nonproportional basis (i.e. when the direction of change and not the magnitude is considered)

(*b*) The %-age correlation of the nitrate reductase: ribulose 1–5, diphosphate carboxylase ratio (i) and (ii) as for a.

LEAF	% CORRELATION WITH Γ			
NO.	a (i)	b (i)	a (ii)	b (ii)
1	27	47	53	73
2	54	69	77	85
3	64	75	83	91
4	22	79	67	89

activity and Γ do not correspond, with respect to leaf position. The carboxylating enzyme activity was found to increase with each new leaf formed, Graph 'a' Figure 5, whereas the average Γ was observed to remain relatively constant irrespective of leaf position. Under these conditions, if photorespiration remained constant, one would have expected the Γ to decrease, with increased carboxylating activity found with each new leaf produced, but this was not observed to be the case. This observation, together with observed rhythmic fluctuation of carboxylating enzyme activity, further supports the idea that the equilibrium of carbon dioxide uptake and output is probably in a continual state of flux.

Both glycollate oxidase activity and nitrate reductase activity alone, show no correlation with the observed Γ. Unlike the carboxylating enzyme, the activity of these two enzymes show no rhythmic pattern, and the pattern of activity varies from leaf to leaf. However, the overall levels of activity of these enzymes also rise with each new leaf formed of those studied, and exhibit a general decrease in activity with age, indicating a possible relationship with ribulose 1—5, diphosphate carboxylase activity. The observed rise in glycollate

FIG. 1.

Leaf 1. The effect of age on the Γ (Graph 'b'), and the enzymes nitrate reductase, glycollate oxidase and ribulose 1–5, diphosphate carboxylase (Graph 'd'). Graph 'a' is the calculated ratio of nitrate reductase to ribulose 1–5, diphosphate carboxylase (●—●). Where this ratio is divergent from the Γ the expected position is marked by a clear circle (○ ... ○) and numbered (top row). The lower row of numbers represents those points which are divergent when correlated on a nonproportional basis (i.e. when the direction of change and not the magnitude is considered). These points are marked by a dashed line and clear triangle (△—△) where necessary. Graph 'c' is the calculated ratio of glycollate oxidase to ribulose 1–5, diphosphate carboxylase (●—●). The explanation of the graph is as for graph 'a'.
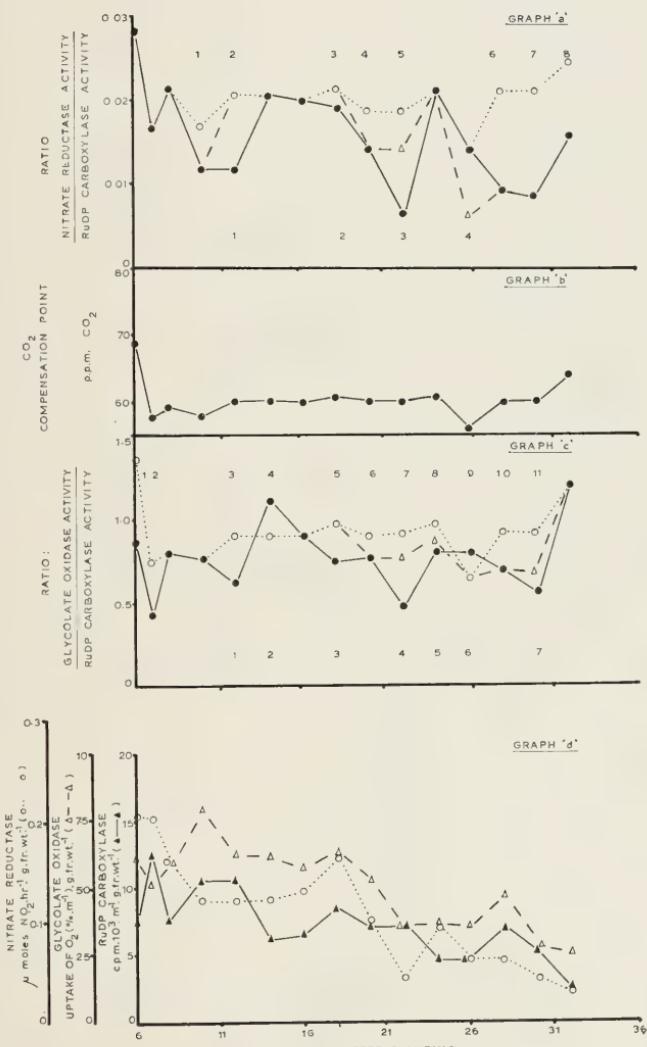
FIG. 1.
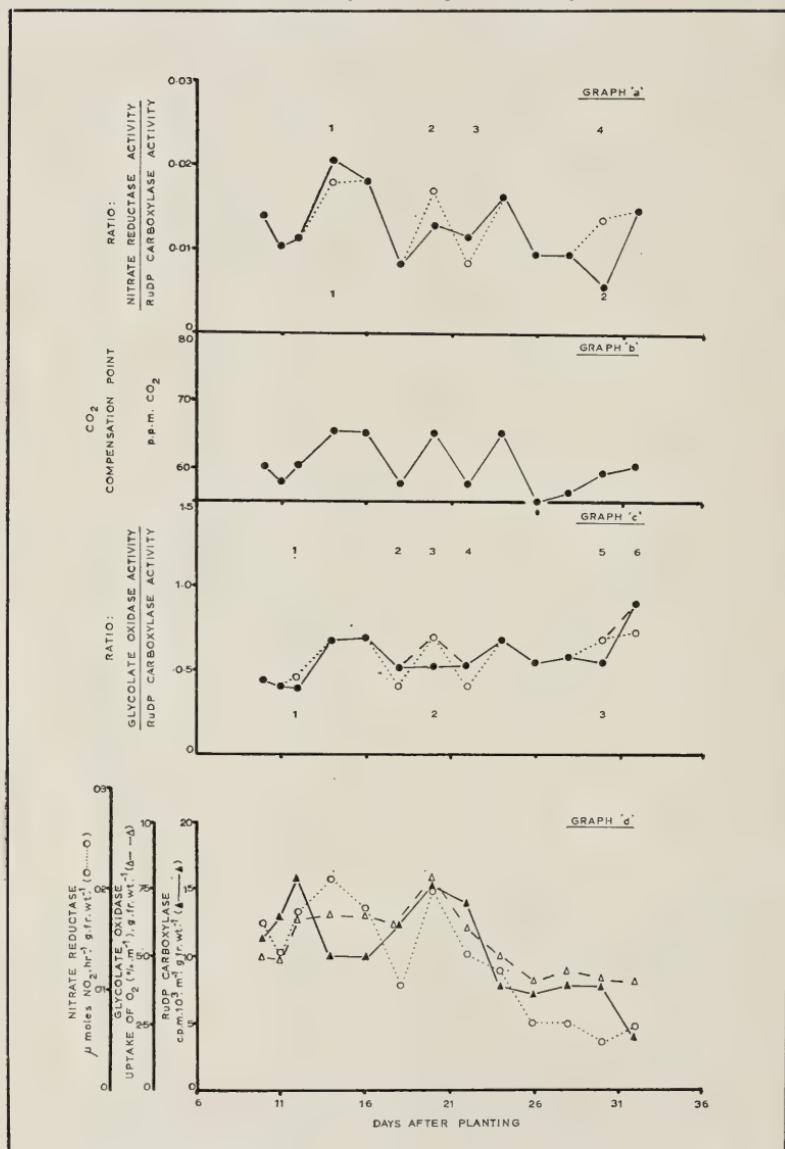
FIG. 2.
Leaf 2. Explanation as for Fig. 1.
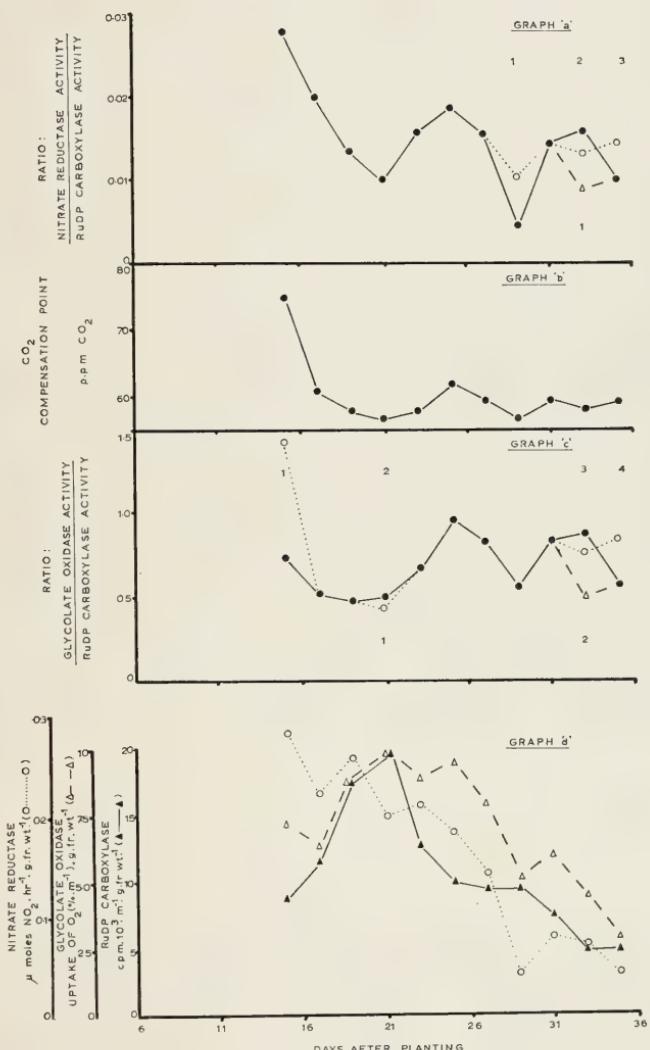
FIG. 3.
Explanation as for Fig. 1.

oxidase, and nitrate reductase did not result in any general rise in Γ. The observed increase in nitrate reductase activity with ascending leaf position, differs from the observations made by Carr and Pate (1967) using 'field pea'. As the enzymes ribulose 1—5, diphosphate carboxylase is directly responsible for carbon dioxide fixation, and glycollate oxidase has been suggested as being directly involved in photorespiration, it was anticipated that the ratio of these two enzymes would give a good correlation with the observed Γ. However, when the ratio of these two enzyme activities was determined, Graph 'c' Figures 1—4, only a low order of correlation was observed, particularly in leaves one and four. A possible explanation for this observation, is that the enzyme glycollate oxidase participates in the glycollate—glyoxylate shunt as well as in the decarboxylation pathway involved in photorespiration, as suggested in the proposed photorespiration pathway (Tolbert *et al*, 1969).

However, when the ratio of nitrate reductase activity to ribulose 1—5, diphosphate carboxylase activity was plotted Graph 'a' Figures 1—4, and this compared with the observed Γ, a greatly improved correlation was found. This suggests that nitrate reductase activity is indirectly related to photorespiration activity in plants receiving their nitrogen solely as nitrate. Further, this result suggests that under these conditions nitrate reductase activity, is more reliable than glycollate oxidase activity as an indirect measure of photorespiration, due to the product of nitrate assimilation being probably associated with amination steps thought to be involved in photorespiration. If this is the case, then it is thought a major function of photorespiration could be the supply of carbon skeletons from glycollate for amino acid metabolism in the light. Under these circumstances a relatively high Γ as observed in the early stages of developing leaves, could indicate carbon flow into amino acid formation, rather than sugar formation, when a lower Γ would be expected.

Further indirect support for a possible connection between nitrate assimilation and peroxisomal metabolism is suggested by Ruis and Kindl (1971) who suggest from their results that leaf peroxisomes may have more importance in amino acid metabolism than was previously assumed. Beevers and Hagerman (1969) observed that oxygen was essential for the assimilation of nitrite, this could be explained by the fact that oxygen is required for photorespiration, which we suggest is associated with nitrite assimilation. In labelling experiments using $C^{14}O_2$ Ongun and Stocking (1965) observed that after fifteen minutes of photosynthesis of the amino acids present in the leaf, the labeled carbon was predominantly in the soluble amino acid fraction namely serine, glycine, aspartate and alanine. All these amino acids are involved the proposed photorespiration pathway, Figure 6.

Based on the above we suggest that the level of Γ could therefore be con-
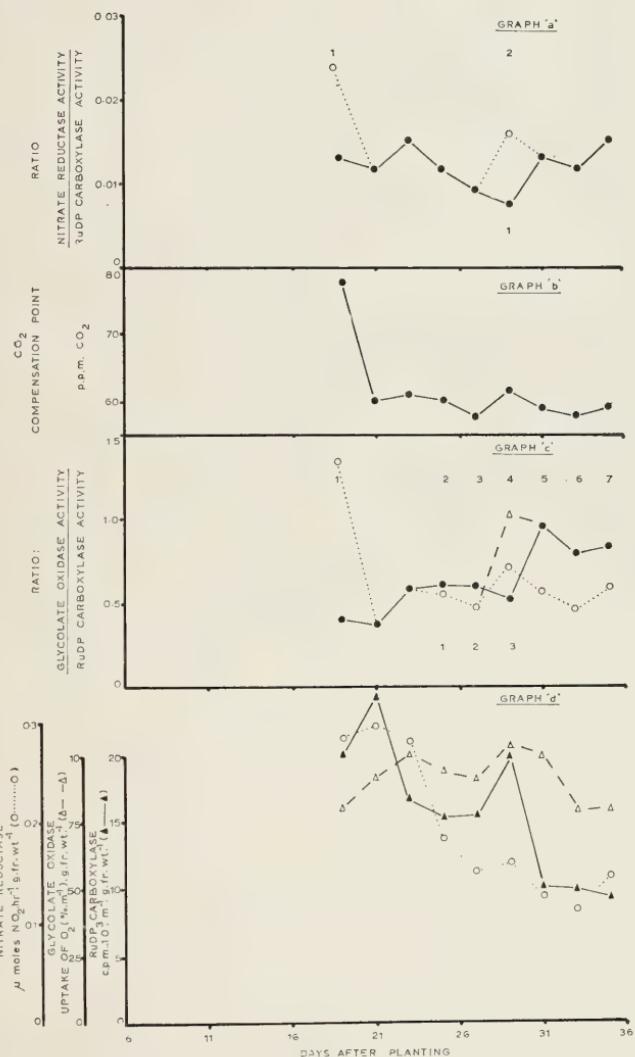
FIG. 4.
Leaf 4. Explanation as for Fig. 1.
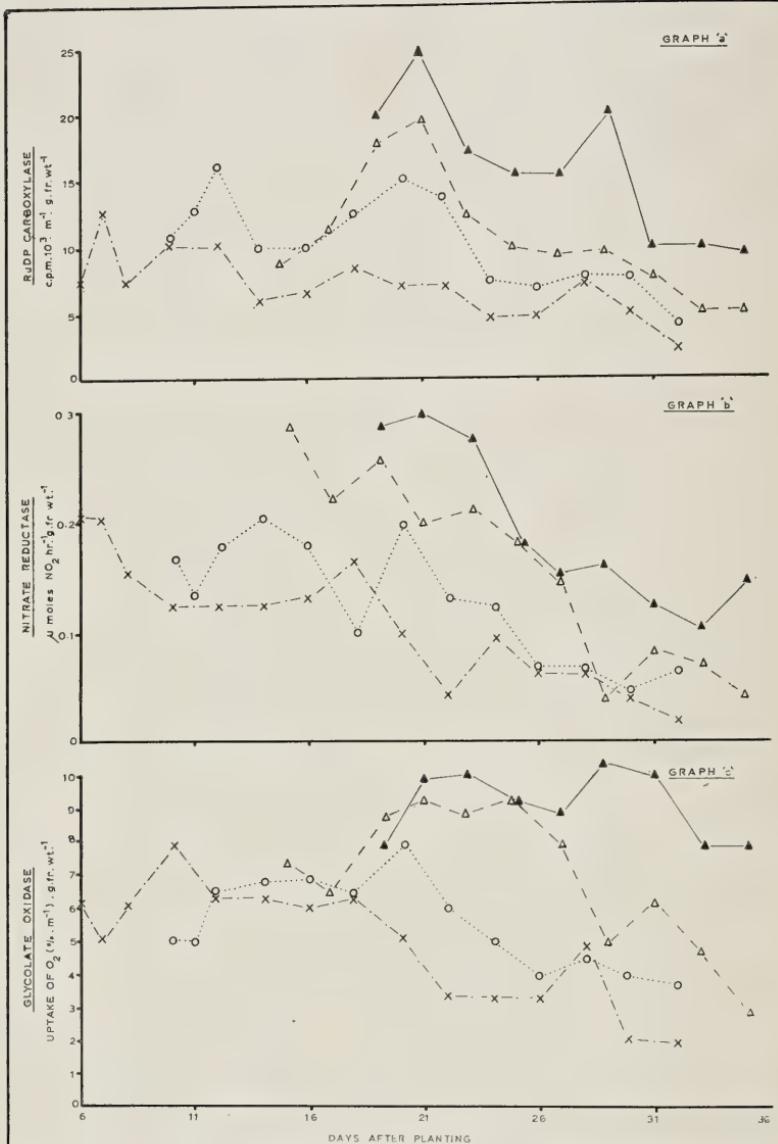
Fig. 5.

The effect of age on the ribulose 1-5, diphosphate carboxylase activity (Graph 'a'), nitrate reductase activity (Graph 'b') and glycollate oxidase activity (Graph 'c') for the four leaves; sampled. Leaf 1 (x--x); Leaf 2 (○ ... ○); Leaf 3 (△—△); Leaf 4 (▲—▲).

trolled by the demand for either amino acids or sugars. It could also be regulated by the level of available nitrogen.

Finally, it is suggested that the significance of nitrate reductase activity as a possible indirect measure of photorespiration could be affected in one or all of the following ways:

(*a*) The product of nitrate assimilation may be utilized outside the peroxisome.

(*b*) The influence of nitrogen supply for amino acid formation from sources other than the peroxisomal cell nitrate assimilation.
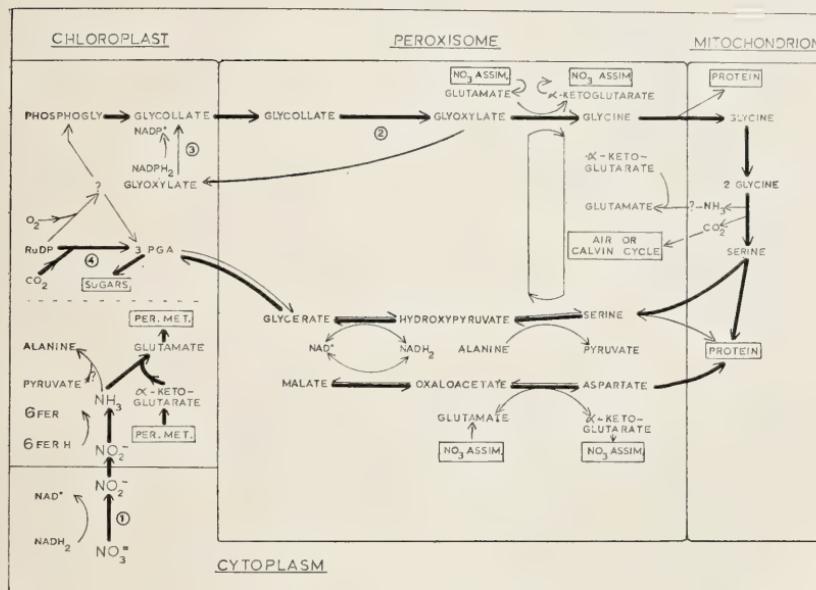
FIG. 6.
Proposed flow diagram modified from Tolbert (1971). (1) Nitrate reductase; (2) Glycollate oxidase; (3) NADPH-glyoxylate reductase; (4) ribulose 1–5, diphosphate carboxylase; NO_3 ASSIM-Nitrate assimilation; Per. Met. -Peroxisomal metabolism.

(*c*) The formation of serine may occur through the reverse reaction sequence namely 3 Phosphoglyceric acid → Glyceric acid → Hydroxypyruvate → Serine as shown in Figure 6.

(*d*) Glycine may be utilized directly prior to the decarboxylating step as shown in Figure 6.

CONCLUSIONS

The results of the work presented, demonstrate the following points:

(1) CO_2 compensation point is not a fixed point, but fluctuates.

(2) Ribulose 1—5, diphosphate carboxylase activity varies as follows:

    (i) Activity increases with each successive leaf studied.

    (ii) Activity shows a rhythmic pattern of fluctuation, synchronized in the four leaves studied.

    (iii) A general decline in activity occurs as a leaf ages.

(3) Overall levels of glycollate oxidase and nitrate reductase activity increase within each succeeding new leaf studied up to leaf four.

(4) The overall level of glycollate oxidase and nitrate reductase activity drop steadily as a leaf ages.

(5) Nitrate reductase activity appears to be closely coupled with photorespiration in barley plants supplied with nitrate as sole source of nitrogen.

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TWO NEW SPECIES OF *CARALLUMA* FROM THE WESTERN PART OF THE CAPE PROVINCE.

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ABSTRACT

Two new species of *Caralluma* from the Western part of the Cape Province are described. Attention is drawn to the similarity in vegetative characters of many species encountered in this area and the need for a more intensive investigation of this species-complex is alluded to.

UITTREKSEL

TWEE NUWE *CARALLUMA* SOORTE VANAF DIE WES-KAAP.

Twee nuwe *Caralluma* soorte vanaf die westelike deel van die Kaap Provinsie word beskryf. Aandag word gevestig op die eendersheid van die vegetatiewe kenmerke van baie spesies wat in die deel aangetref word en die behoefte vir meer intensiewe ondersoek in hierdie spesies kompleks word aangegee.

Caralluma swanepoelii Lavranos nov. sp., affinis *C. dependenti* N.E.Br. sed caulibus brevibus, basi radicantibus, dense confertis, corolla rotata nec dependente differt.

Planta succulenta, aphylla, *caulibus* 2—6 cm longis, 10—12 mm crassis e basi radicantibus, dense confertis, tetragonis, angulis rotundatis, tuberculatis-tessellatis, tuberculis dente acuto, duro, brunneo armatis; *floribus* ex parte apicale caulium productis haud dependentibus; *pedicellis* strictis, 1,5 mm longis, 0,75 mm diam., glabribus, viridibus rubrolineatis; *sepalis* 2 mm longis, deltoideis, acutis; *corolla* 12 mm diam., rotata, disco carnoso, 4,5 mm diam., albo brunneo-violaceo maculato, lobis 3,75 mm longis, 3 mm latis, ovatis deltoideis, basi albis, brunneo-violaceis maculatis, apicem versus omnino brunneo-violaceis, glabribus sed marginibus levissime deflexis, pilis contortis, violaceis ornatis; *corona* supra corollam 1,75 mm elevata, duplici, *lobis exterioribus* apice fuscis brunneo-violaceis, patentibus-adscendentibus, apice bifido segmentibus divergentibus, curvatis; *interioribus* itidem fuscis brunneo-violaceis, linearibus, apice rotundatis-emarginatis.

Type material: South Africa; Cape Province; 3119 AA (Calvinia). On low hills on the farm Kleine Kloof, alt. appr. 400 m; *Swanepoel in Lavranos* 8371 (PRE holotype).

Plants succulent, leafless, the densely congested *stems* 2—6 cm long, 10—12 mm thick, ascending, rooting at their base, 4-angled, the angles rounded, tuberculate-tessellate, each tubercle armed with an acute, hard, brown tooth; *flowers* produced from the apical part of the stems, not dependent; *pedicels*

FIG. 1
C. ortholoba face view of flower × 10

FIG. 2
C. ortholoba plant × 0,5, showing habit.

straight, 1,75 mm long, 0,75 mm diam., glabrous, green with longitudinal reddish lines; *sepals* 2 mm long, deltoid, acute; *corolla* 12 mm diam., rotate with a rather fleshy disc 4,5 mm diam., which is whitish with violet-brown spots, the lobes 3,75 mm long 3 mm broad, ovate-deltoid, whitish with violet-brown spots at base, thereafter entirely violet-brown, glabrous except for contorted, violet-reddish hairs on their very slightly reflexed margins; *corona* elevated 1,75 mm above the corolla, the *outer lobes* spreading—ascending the segments of their forked, dark violet-brown apex diverging, curved; *inner lobes* as the outer in colour, linear, with a rounded emarginate apex.

C. swanepoelii, named after its discoverer, Mr. J. P. Swanepoel of Somerset West, Cape Province, was found about 20 km NE of Nieuwoudtville, in the Calvinia District, growing under the protection of low Karoo bushes on undulating, gravelly ground, in association with *Euphorbia cf brakdamensis* N.E.Br., *Aloe krapohliana* Marl., *Echidnopsis framesii* Wh. & Sl., many other Stapelieae, species of *Oxalis, Lachenalia* etc.

The area around Vanrhynsdorp and Nieuwoudtville has yielded an unusually large variety of species of *Caralluma*, many of which are quite distinct florally but scarcely so in their vegetative characters. The fact that some of these species, such as *C. cincta* Lukh., *C. villetii* Lukh. or *C. inversa* N.E.Br. are rare is borne out by the fact that the first two have not been found again since the original collection, while *C. inversa*, originally collected in 1903 "in the Clanwilliam District", was found again, for the first time since its discovery and again in one single specimen, near Vanrhynsdorp by Mr. Swanepoel.

C. swanepoelii is closest allied to *C. dependens* N.E.Br. from which, however, it differs by its flowers which are not at all dependent, its corolla which is rotate with a fleshy disc and by its much shorter, semi-prostrate or ascending stems which form dense mats and differ markedly, in this regard at least, from the long erect stems characteristic of *C. dependens*.

Caralluma ortholoba Lavranos nov. sp., affinis *C. hottentotorum* (N.E.Br.) N.E.Br., sed lobis corollae erectis, late deltoideis, corolla omnino glabra et minute purpurea maculata differt.

Planta succulenta, aphylla, *caulibus* confertis, basi radicantibus, 4—10 cm longis, a 20 mm crassis, 4-vel 5-gonis, viridibus, prominente dentatis, dentibus pungentibus, brunneis; *floribus* 2—5 simul vel deinceps e *pedunculis* pulviniformibus productis; *bracteis* pluribus, minutis; *pedicellis* teretibus, 1,5 mm longis; *corolla* companulata, glabra, flavescente, sparse et minute purpurea maculata, expansa 9 mm diam., tubo ca. 2,3 mm longo, 4 mm lato, lobis erectis, late deltoideis, acutis, 3 mm longis et ca. 3 mm latis; *corona* duplici, fusca purpurea, 3,5 mm diam., *exteriore* cupulari, lobis 5, erectis, brevissimis, bifidis, *interiore*

Fig. 3
Caralluma swanepoelii; portion of flowering stem × 2,5

Fig. 4
C. swanepoelii, face view of flower, ca × 10

lobis linearibus, apice acutiusculis, supra antheras arcte incumbentbus sed ab eas valde brevioribus.

Type material: South Africa, Cape Province, 3118 DD (Vanrhynsdorp), some kilometres WSW of the Langeberg on sandy soil in the shade of small shrubs and tufts of desert grass; Lavranos 8227, coll. 12 April 1971 (PRE, holotype).

Plants succulent, leafless, the *stems* densely congested and rooting at their base, 4—10 cm long, about 20 mm thick including the prominent acute, brown-tipped, pungent teeth, 4- or 5-angled; *flowers* 2—5 arising together or successively from cushion-like *peduncles* in the grooves between the angles of the stems; *bracts* several, minute; *pedicels* terete, 1,5 mm long; *sepals* deltoid, acute, green, 2 mm long; *corolla* glabrous, campanulate, yellowish with distant, minute, irregular purple blotches, when expanded 9 mm diam., the tube ca. 2,3 mm long, 4 mm wide, the lobes erect, broadly deltoid, acute, 3 mm long and about as wide; *corona* double, dark purple, 3,5 mm diam., the *outer* cupular with 5 very short, erect, bifid lobes, the *inner* lobes linear, with a rather acute apex, incumbent upon but much shorter than the anthers.

Only a few specimens of this new species were found at the type locality and held to represent *C. hottentotorum.* Their true identity was, however, established when they flowered at Johannesburg and Somerset West, in June 1971.

C. ortholoba is virtually indistinguishable, vegetatively from the majority of the species of *Caralluma* found in the Calvinia and Vanrhynsdorp Districts and parts of Namaqualand. It is most closely allied to the various forms of *C. hottentotorum* but is readily distinguished by the erect and broadly deltoid corolla lobes of its flowers which are spotted with purple whereas in *C. hottentotorum* the flowers are generally yellowish, without spots and, most important, with spreading and proportionally narrower corolla lobes. Also, in the new species, the corona is wholly dark purple while in its ally it is always yellowish.

Both species dealt with in this paper emanate from the same general area in the Western Cape Province and their discovery emphasises the need for a closer investigation, by means of organised collecting and subsequent comparative study, of the numerous Stapelieae that grow in this arid area.

NOTES ON THE ECOLOGY OF *AZORELLA SELAGO* HOOK. f.

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ABSTRACT

The umbelliferous cushion plant *Azorella selago* Hook f. is one of the most important constituents of Subantarctic plant communities. The species was studied during a fifteen months survey of the vegetation of Marion Island, South Indian Ocean. Aspects reported on include the species distribution on the Island, rôle in the vegetation, vitality, growth form, leaf production, annual height increase, age of cushions and primary aerial production.

UITTREKSEL

NOTAS OOR DIE EKOLOGIE VAN *AZORELLA SELAGO* HOOK. f.

Die polplant *Azorella selago* Hook f. (Umbelliferae) is een van die belangrikste bestandele van subantartiese plantgemeenskappe. Die spesies was gedurende 'n vyftien maand lange ondersoek na die plantegroei van Marion Eiland (in die Suidelike Indiese Oseaan) bestudeer. Aspekte waaroor verslag gedoen is sluit in die verspreiding van die spesies oor die Eiland, rol in die plantegroei, lewenskrag, groei vorm, blaar produksie, jaarlikse hoogte toename, ouderdom van pol en primêre bogrondse produksie.

INTRODUCTION

Azorella selago Hook. f. is one of the most prolific and ubiquitous vascular plants of the subantarctic islands. It plays an important and conspicuous rôle in the vegetation of the Marion and Prince Edward Islands, Iles Crozet, Archipel de Kerguelen, Macquarie and Heard Island, being absent from only South Georgia in the Subantarctic zone. Its remarkable growth form (Figures 1 and 2) immediately attracts the attention of visitors to the islands, not only as an outstanding example of adaptation to the harsh environment, but also as a welcome cushion for the weary explorer of these rugged, tractless islands.

During an extensive survey of the vegetation of Marion Island (Huntley, 1968, 1971) it was possible to investigate some aspects of this interesting plant's ecology. Neither time nor facilities were available for sophisticated autecological studies; it is hoped however that the preliminary findings presented here will stimulate a detailed study of this most interesting plant.

STUDY AREA

Marion Island (46°55′S, 37°45′E) is an extremely isolated volcanic island lying in the South Indian Ocean. The Island experiences an isothermal oceanic

FIG. 1.

Azorella selago growing in a fjaeldmark community on an exposed ridge on Prince Edward Island. Tufts of the grass *Agrostis magellanica* grow 'epiphytically' on the *Azorella selago* cushions while numerous balls of the mosses *Andreaea regularis* and *Ditrichum strictum* occupy the loose lava between the cushions.

Fig. 2.

Exceptionally large spongy cushions of *Azorella selago* forming an almost continuous carpet over black lava on the west coast plain of Marion Island.

tundra climate, with a mean temperature of 5,5°C (range of mean monthly temps:
3,6 to 7,8°C). Precipitation is recorded on over 300 days per annum, the total
averaging 2 576 mm. The Island is approximately 300 square kilometers in area
with the topography rising steeply from the cliff-lined coast to the highest peaks
at slightly above 1 200 m.

In common with other subantarctic islands, no trees are found on Marion
Island, the vegetation comprising short, closed herbaceous communities on the
lowlands and open cryptogamic communities at altitudes above 500 m.

STUDY METHODS

As opportunities presented themselves, various aspects of the biology of
Azorella selago were studied. While most of these studies formed part of the
extensive ecological survey certain aspects such as growth rate, growth form,
vitality, etc., were given special attention. Populations rather than individuals
were studied and as a rule at least twenty plants from each population were
sampled where quantitative measurements were taken.

Distribution of Azorella selago on Marion Island

Over 1 500 km were covered on foot during the survey of the Island. Thus a
comprehensive idea of *A. selago*'s distribution was obtained.

Rôle of Azorella selago in the Islands vegetation

A quantitative and qualitative study of the plant communities was made
using a quadrat technique (Huntley 1967, 1968, 1971) in which 457 stands of the
various communities were examined. In each quadrat the cover, sociability and
vitality of plants were recorded in addition to habitat factors.

Vitality

The vitality of *Azorella selago* was recorded qualitatively following the Zoller
(1954) scale, according to which 1 = strongly reduced, sick or very weak;
2 = clearly reduced vitality, but still healthy; 3 = normal and 4 = very strong
and vigorous. A quantitative measure of the vitality of *A. selago* populations
growing in several habitats was obtained by measuring the length and breadth
of leaves taken at random from a large sample.

Growth form

Typical examples of the various cushion forms exhibited by *A. selago* were
examined in profiile and scale drawings made of aerial and subterranean organs.

Leaf production

A. selago leaves turn brown in autumn and it is thus easy to distinguish the
new green leaves produced the following spring. It was therefore possible to

count the number of new leaves produced per shoot through the growth period. Populations of *A. selago* in seven habitats were examined at fortnightly intervals during the 1965–66 season.

Annual height increase and age of cushions

Slender stakes of 30 to 50 cm in length were inserted into cushions and secured in the soil substrate, care being taken not to damage branches or roots. The stakes were marked at the upper end by two lines 1 cm apart, the lower of these being brought opposite the smooth convex surface of the cushion. The stakes were placed in position in May 1965 and the height increase measured in late March 1966 and early April 1969. Height increase was determined by measuring the distance between the new cushion surface and the upper line, and subtracting from 1 cm.

Primary aerial production

Normal harvest methods could not be applied to measure the primary aerial production of *A. selago*. This is due to the plant's compact cushion growth form which makes clipping of an even sample of the season's growth impossible, and secondly to the very low cover and scattered pattern of cushions which would require an impractically large number of samples for any measure of accuracy. Instead of sampling a community as a whole, individual cushions were removed *in toto* in April 1970 and the leaf production of the 1969–70 season was estimated by removing and weighing samples of shoots produced during that season. Only three cushions were avalable for study, one from herbfield and two from fjaeldmark. The mean number of shoots per 100 sq. cm were counted in triplicate and the mean dry weight of samples of 200 heads determined. An estimate of the net primary production for the individual cushions, and for the communities in which they occurred could then be calculated.

RESULTS AND DISCUSSION

Distribution of Azorella selago on Marion Island. A. selago proved to be the most ubiquitous vascular plant on the Island, occuring from sea level to the extreme limit of vascular plant growth at 765 m, (Huntley 1970). With the exception of sites permanently submerged in over 20 cm of water, it may be said that *A. selago* occurred in every habitat in which vascular plants were recorded.

Rôle of A. selago in the vegetation. The importance of *A. selago* in the vegetation may be gauged by the fact that it occurred in 71 % of the 457 quadrats (10 × 10 m) examined in the vegetation survey, followed by *Agrostis magellanica* (65 %), *Poa cookii* (57 %) and *Ranunculus biternatus* (47 %) in order of frequency. *A. selago* was present in all twelve of the "noda" recognised in the vascular vegetation (Huntley 1968, 1971) and was the dominant species in three of these.

Besides its rôle as the dominant plant in many communities, it is also a pioneer of many areas, stabilizing recent lava flows and scoreaceous slopes and providing a substrate for colonization by less hardy species such as *Ranunculus biternatus, Montia fontana, Callitriche antarctia, Colobanthus kerguelensis, Agrostis magellanica, Poa cookii, Uncinia dikei* and many other species which grow 'epiphytically' on the cushions.

Vitality. A. selago is certainly the most robust plant on the Island, with the widest ecological amplitude. Table 1 presents a summary of the observed vitality of *A. selago* populations growing in the main habitat types available to vascular plant growth on the Island.

TABLE 1

Vitality of *Azorella selago* populations occupying various habitats on Marion Island, according to the scale of Zoller (1954).

Habitat conditions	Vitality	Plant community
well drained eutrophic soils	4	Azorella selago herbfield
sites protected from wind	4	Azorella selago herbfield
sites exposed to strong wind	3	Azorella selago fjaeldmark
sites exposed to heavy salt spray . . .	2	Tillaea moschata halophytic herbfield
sites occupied by birds and seals . . .	2	Poa cookii tussock grassland
waterlogged oligotrophic soil	2	Agrostis magellanica mire
sites temporarily or permanently submerged	1	Tarn hydrosere

Growth form. One of the most interesting features of *A. selago* is its cushion-like growth form which is perhaps surprising in a member of the carrot family. This form is not unique to Azorella however; as early as 1912 Hauri described 337 cushion forming flowering plants, from 34 families. The possible advantages of this growth form are discussed by Huntley (1968, 1971).

The growth form of *A. selago* is most typically a hard compact cushion of 15 30 cm height and 20 40 cm diameter. Such cushions are extremely resistant to damage or injury by frost or wind action. Reiche (1907) remarks that a cushion of *Azorella madreporica* of Chile turned off a revolver bullet!

The shape of individual cushions varies considerably. In *Azorella-Poa* Montane Herbfield for example, the cushions spread out forming a continuous carpet over several score square metres, while in *Azorella selago* Herbfield on the Island's west coast plain, enormous cushions in excess of 1 m height are found. These cushions are extremely spongy and offer no resistance to compression.

In plan the cushions are rarely circular except in very young plants. Most cushions in exposed sites develop an arcuate shape, advancing into the wind. The rate of advance appears to be extremely slow, cushions marked in February 1965 had advanced less than two centimetres by April 1969. Nevertheless the

position of the plants is definitely not static, as witnessed in cushions that had advanced several decimeters over pipelines, posts and other structures erected fifteen to twenty years ago.

In profile, the cushions exhibit a great diversity of form. In optimum habitats the cushions are large and spongy, contrasting with the small compact cushions
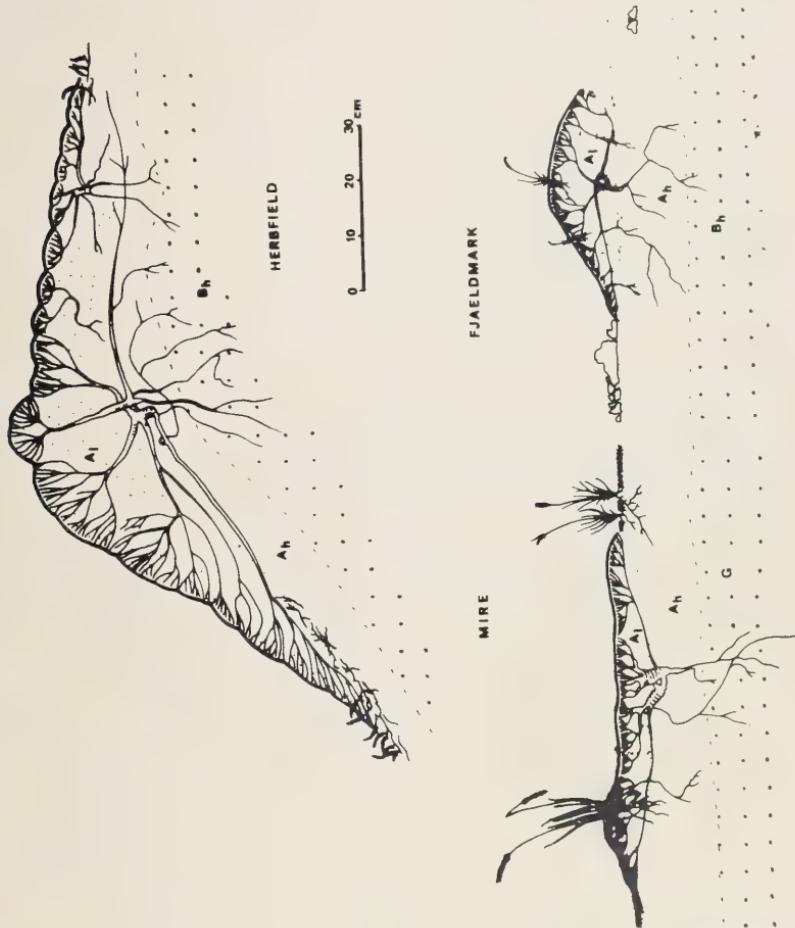
FIG. 3.
Profile diagrams of typical cushions of *Azorella selago* examined in various habitats.

of windswept fjaeldmark. In swampy sites the cushions never attain more than a few centimeters in height, usually spreading out as a rough mat (Figure 3).

Leaf production. During 1965 *Azorella selago* cushions on Marion Island ceased vegetative growth in mid-April and by mid-June the cushions were dark brown. Early in July a few new green leaf buds were noted in cushions of lowland and well protected upland populations and by the end of August all plants examined had at least one new leaf (Figure 4).

In the optimum habitat studied, well drained eutrophic soils in a sheltered valley at 140 m a.s.l., an average of nine new leaves per shoot had opened fully by mid February 1966 compared with six in an exposed herbfield community on well-drained eutrophic soils, five in ill drained oligotrophic mire and five in very exposed fjaeldmark.

By mid-March 1966 the full complement of new leaves had appeared, and towards the end of March most leaves showed signs of autumnal colouring. With the possible exception of *Poa cookii* and *Poa annua*, *Azorella selago* appears to have the longest growth season of Marion Island vascular plants, ranging from seven and a half months in exposed upland sites to eight and a half months in protected habitats.

Annual height increase of cushions. The height increases recorded in five populations during the period May 1965 to April 1969 are presented in Table 2. The mean annual height increase in the fjaeldmark populations was only 1,8 mm, while that of the most robust population growing in optimum habitat conditions was only 6,0 mm per annum. This latter figure compares with that of $\frac{1}{4}$ inch (6,35 mm) given by Taylor (1955) for *A. selago* on Macquarie Island. Taylor (*op. cit.*) does not state in which habitat the measurement was made however; it is possible that in exposed fjaeldmark communities the growth may be much less than the figure he gives.

TABLE 2

Height increase in *Azorella selago* cushions during the period 1965–69.

site	plant community (Huntley, 1968)	altitude, m	exposure to wind	height increase, mm		
				1965–66	1965–69	mean annual
1	Azorella selago fjaeldmark	150	exposed plain	2,4	7,3	1,8
2	Azorella selago fjaeldmark	270	very exposed col	2,4	—	—
3	Azorella selago fjaeldmark	145	very exposed ridge	1,6	7,3	1,8
4	Agrostis magellanica mire	130	sheltered valley	0,7	2,6	0,6
5	Azorella selago herbfield	140	sheltered valley	7,6	24,0	6,0
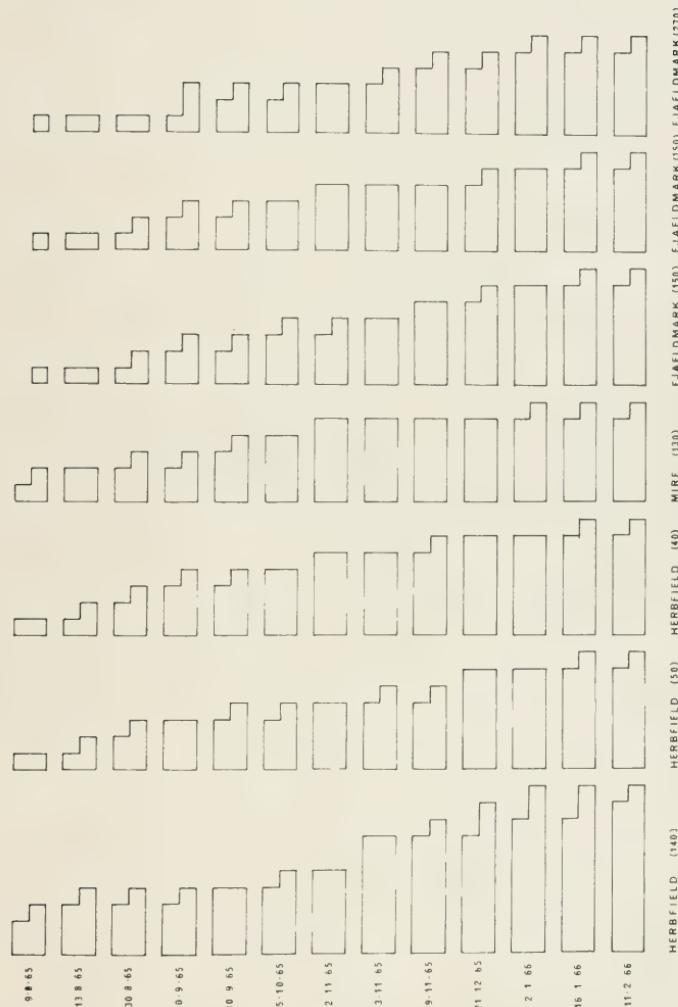
FIG. 4.

Time of appearance of new leaves on branches of *Azorella selago* cushions in populations in herbfield, mire and fjaeldmark communities. Small square represents new bud present, upright rectangle represents new leaf fully opened. The altitude of each population is given in parentheses.

Using the Marion Island data, it is possible to estimate the age of cushions in the various habitats. The height of twenty medium to large cushions in the fjaeldmark populations averaged 15 cm, indicating an age of approximately 83 years for cushions of this size and over a hundred years for the larger cushions. Calculations based on the data for herbfield and swamp communities were of the same order. While it is clear that one cannot assume an even rate of growth throughout a cushion's life history, the data presented above do suggest that one is dealing with extremely slow growing plants, some of which must be of considerable age despite their small size.

TABLE 3

Shoot production data for three *Azorella selago* cushions collected on Marion Island at the end of the 1969–1970 growth season.

Sample no.	1	2	3
plant community	Herbfield	Fjaeldmark	Fjaeldmark
% cover of A. selago in community	45	10	15
surface area of cushion, sq. m	0,725	0,225	0,095
average no. of shoots per sq. m	24500	38000	42400
average weight per shoot, gms	0,0392	0,0225	0,0211
shoot production, gms per cushion	697	192	85
shoot production, gms/m²	960	854	895
shoot production, gms/m² for community . .	433	85	134
shoot production, gms/m²/day for community .	1,8[1]	0,4[2]	0,6[2]

1 based on growing season of 255 days
2 based on growing season of 225 days

Primary aerial production. The results of the shoot production measurements are presented in Table 3. These data must be regarded as tentative, pending more detailed studies. The figures do give an indication of the potential productivity of *Azorella selago* however. If it can be assumed that the shoot production in the extensive carpets of *Azorella selago* found in *Azorella selago* Herbfield and *A. selago—Poa cookii* montane herbfield is of the same order as that for the cushions examined in this study, the annual shoot production would be in the region of 960 gms/m² or 3,5 gms/m²/day during the growth season of approximately 255 days. The former figure is approximately six times as high as comparable data for arctic and alpine tundras (Bliss 1966) while the latter figure is within the range of 1 to 4 gm/m²/day for the same areas (Bliss 1962) which experience a much shorter growing period.

Thanks are also due to Dr S. S. du Plessis, Director of Nature Conservation, Transvaal, for granting me study leave to re-visit Marion Island in 1969 to conduct further investigations into the growth of *Azorella selago*.

Some of the data presented in this paper formed part of a chapter in a thesis accepted by the University of Pretoria towards an M.Sc. degree. It is a great pleasure to thank Prof. H. P. van der Schijff for his encouragement and help in the preparation of the final manuscript.

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AERIAL STANDING CROP OF MARION ISLAND PLANT COMMU-NITIES

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Abstract

Aerial standing crop estimates for three closed lowland vascular plant communities on Marion Island, (46°55′S, 37°45′E) are presented. Estimates ranged from 328,5 | 29,0 gm/m² for *Agrostis magellanica* mire to 798,7 ± 32,0 gm/m² for *Blechnum penna marina* fernbrake. The estimates are considerably higher than figures for alpine and arctic tundras and higher than those for certain tropical grasslands.

Uittreksel

BOGRONDSE OES VAN MARION EILAND PLANTGEMEENSKAPPE.

Die bogrondse oesskatting vir drie geslote laagland vaargemeenskappe op Marion Eiland (46°55′S, 37°45′O) word aangebied. Skattings wissel van 328,5 ± 29,0 gm/m² vir *Agrostis magellanica* moeras tot 798,7 ± 32,0 gm/m² vir *Blechnum penna marina* gemeenskap. Die skattings is aansienlik hoër as syfers vir alpynse en arktiese toendra en hoër as die van sekere tropiese graslande.

Introduction

Since the inception of the International Biological Programme, considerable interest has been stimulated in the field of production ecology. As a result a wealth of information is becoming available on the primary production of temperate and tropical communities. With the exception of work by Bliss, Billings and co-workers in North America however, very little is known of the productivity of the polar regions, especially in the Southern Hemisphere. The data presented in this paper, although based on a very small study, serve to illustrate the exceptionally high yields produced in certain oceanic tundra plant communities.

Study Area

Marion Island (46°55′S, 37°45′E) is an isolated Subantarctic island in the South Indian Ocean. The island experiences an isothermal oceanic tundra climate, with a mean temperature of 5,5°C (range of monthly means 3,6 to 7,8°C) and annual precipitation exceeding 2 500 mm, precipitation being

recorded on an average of 311 days per year. The island is approximately 300 km² in area and rises to peaks of 1 200 m.

METHODS

Extensive ecological studies were conducted during 1965–66 (Huntley 1968, 1971). These studies indicated that aerial standing crop reaches a peak from late March to mid April on Marion Island. The data presented in this paper were collected during a two day visit in April, 1969.

Representative stands of three unistratal herbaceous communities were selected for study. The method of stand selection and analysis is described by Huntley (*op. cit.*). In each stand twenty 0,2 m² circular clip samples were collected. The samples were distributed in two rows of ten, rows and samples being 2 m apart. All vascular plants within the circle demarcated by a wire ring were hand clipped to a height of 2,5 cm above the soil surface. The clipped material was placed in paper bags and dried in a heated room at the Meteorological Station. On return to South Africa the samples were dried for 48 hours at 95°C in an electric drying oven and weighed on cooling.

RESULTS

Table 1 presents habitat and floristic data for the three stands studied. The stands are typical of the communities they represent as described by Huntley (1971).

The aerial standing crop measurements are given in Table 2.

DISCUSSION

The data presented in Table 2 appear almost unbelievable if one considers that they are for unistratal, low growing herbaceous oceanic tundra communities. Even *Agrostis magellanica* mire, with only 35% aerial cover and 15 cm height, had a standing crop twice that of tropical grassland studied in Northern Transvaal (68,5—166,6 gm/m², Huntley, 1969).

The figure for *Poa cookii* is approximately half that for *Poa foliosa* (960 gm/m²) on Macquarie Island (Jenkin and Ashton, 1970. This is to be expected as the latter species is considerably larger, from 1 to 1,5 m in height compared with 0,3 m in *Poa cookii*. The standing crop of both these species is considerably higher than most temperate and tropical grasslands.

The most interesting measurement is that for the fern *Blechnum penna-marina*. This species forms extremely dense carpets of fronds seldom exceeding 15 cm height and is especially common on well drained north-facing slopes at low altitudes. The standing crop of this species is of the same order as *Pleurophyllum hookeri* herbfield (760 gm/m²) of Macquarie Island, (Jenkin and Ashton, *op. cit.*).

FIG. 1.

Mosaic of plant communities on Marion Island. The poorly drained plain in the distance is occupied by oligotrophic *Agrostis magellanica* mire. The vegetation of the well drained slope in the foreground includes small stands of *Acaena adscendens* herbfield in the lower left. *Blechnum penna-marina* fernbrake in the centre and an early seral stage of *Poa cookii* tussock grassland on the right.

Data for *Azorella selago* were not collected during this study but this species undoubtedly has the highest standing crop of all Marion Island vascular plants where it forms continuous carpets. The annual shoot production of a cushion from a protected herbfield community was 960 gm/m^2 while values of 854 and 895 gm/m^2 were obtained from cushions growing in fjaeldmark (Huntley, 1972.)

TABLE 1.

Data for 10 × 10 m quadrats examined in stands of (1) *Poa cookii* tussock grassland; (2) *Blechnum penna-marina* fernbrake; (3) *Agrostis magellanica* mire. Marion Island, 1 April, 1969.

Quadrat number	1	2	3
Area of stand, ha	50	0,2	15
Altitude, m	85	20	35
Slope, degrees	30	15	2
Aspect	SE	NE	NE
Height of dominant vascular plants, cm	30	15	15
Vascular plants, % aerial cover			
Acaena adscendens		trace	
Agrostis magellanica		trace	35
Azorella selago		5	
Blechnum penna-marina		95	
Callitriche antarctica	trace		trace
Juncus scheuchzerioides		trace	trace
Montia fontana	trace	trace	trace
Poa cookii	35		
Ranunculus biternatus	trace	trace	trace
Uncinia dikei		trace	5
Mosses, % aerial cover			
Bryum laevigatum			trace
Campylopus arboricola			trace
Ptychomnion ringianum		trace	
Rhacomitrium lanuginosum		trace	trace
Liverworts, % aerial cover			
Blepharidophyllum densifolium			25
Jamesoniella colorata			10
Marchantia berteroana	trace		trace

TABLE 2.

Aerial standing crop, in gm/m^2 dry weight, of stands of three plant communities occuring on Marion Island. 95% Confidence limits, expressed as a percentage of the mean, are given in parenthesis.

Poa cookii tussock grassland	449,0 (17,6)
Blechnum penna-marina fernbrake	798,7 (8,0)
Agrostis magellanica mire	328,5 (17,7)

The above data suggest much higher aerial standing crop for sub-antarctic plant communities than for arctic and alpine tundras, where measurements range from 78 to 192 gm/m² (Klikoff, 1965) and 14 to 348 gm/m² (Scott and Billings, 1964) respectively.

The high standing crop measurements for the Subantarctic Islands cited above apply only to closed communities of vascular plants and much lower biomasses may be expected from open communities, especially those at higher altitudes. Two factors, the virtual absence of herbivores, and the slow rate of organic decomposition due to a perenially cold climate, undoubtedly play a rôle in the development of the high biomass of low land communities, but the high primary productivity remains to be explained. It is clear that a stimulating field of research awaits the production ecologist in the Subantarctic.

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TWO NEW SPECIES OF *ERICA*

H. A. BAKER

ABSTRACT

Two new species of *Erica* from the south western Cape, *E. setociliata* H. A. Baker and *E. insolitanthera* H. A. Baker, are described.

UITTREKSEL

TWEE NUWE *ERICA* SOORTE.

Twee nuwe *Erica* soorte vanaf die Suid-Wes Kaap, *E. setociliata* H. A. Baker en *E. insolitanthera* H. A. Baker, word beskryf.

Erica setociliata H. A. Baker, sp. nov. (Ericaceae-Ericoideae) Ceramia.

Fruticulus plus minusve effusus ad erectus. *Rami* saligni pubescentes, demum glabri et cicatricibus foliorum delapsorum notari. *Folia* 4-nata, 2—2½ mm longa, patentia, recurvata, imbricata, linearia, acutata, sulcata, plus minusve pubescentia et ciliata, semper instructa pilis, longis, albis. setosis, glandulis, pro parte maxima marginalibus. *Flores* terminales, fasciculati 3—8 in capitulis arctis in brevis ramulis, subcalyicinis; pedunculi 1,5 mm longi, pubescentes; bracteae approximatae, 1,5 mm longae, foliaceae, sepaloideae, adpressae, interdum unicis subapproximatis. *Sepala* 1,5 mm longa sed interdum 3 mm, foliacea sed plus pilis, glandulis, albis, setosis. *Corolla* 2 mm longa, cyathiformis, glabra pro parte magna sepalis occulta, alba vel roseola; lobis continuis, obtusis, circa 1 mm longis. *Filamenta* linearia; antherae minus quam 1 mm longae, inclusae, laterales, oblongae, aristatae, poro fere pars dimidio lobi; aristae aliquantum effusae c. 0,3 mm longae. *Ovarium* turbinatum, glabrum; stylo manifesto; stigmate cyathiformi amplo.

Straggling, more or less diffuse shrublet. *Branches* willowy, pubescent, glabrescent and starred with the persistent leaf cushions. *Leaves* 4-nate, 2—2½ mm long, spreading, recurved, imbricate, linear, acute, sulcate, more or less pubescent and ciliate with short hairs but always beset with a few long, setose, glandular hairs, mostly on the margins. *Flowers* terminal, clustered 3—8 in tight heads on short branchlets, subcalycine; peduncles pubescent, 1,5 mm long; bracts approximate, foliaceous and sepal-like, adpressed, one sometimes sub-approximate. *Sepals* foliaceous but with many more of the gland-tipped ciliations, reaching to the top of the corolla-tube or more; the corolla thus

being largely concealed and made viscid by them. *Corolla* 2 mm long, cyathiform, glabrous, white or pink; lobes continuous, rounded, about 1 mm long. *Filaments* slender, linear; anthers included, 1 mm long, lateral, oblong, aristate; pore about half the length of the cell; awns slightly spreading, 0,3 mm long. *Ovary* turbinate, pubescent mainly on top; style just manifest; stigma cyathiform, large.

DISTRIBUTION:

CAPE—3219 (Wuppertal) in rock crevices on summit rock, alt. 1829—1951 m, and on S. facing scree slopes; Sneeuberg (-CA), 1/9 1963, *Esterhuysen* 30286 (holotype, BOL.); Cedarbergen, Tafelberg, c. 1829 m, (-AC), 8/10 1946, *Esterhuysen* 13049 (BOL); Cold Bokkeveld, Blaauwkop, (-CB), c. 1676 m, 1/10/1958, *Esterhuysen* 27915 (BOL); —3319 (Worcester), rocky places c. 1828—1980 m on Keeromsberg (-DA), 5/9/1965, *Esterhuysen* 31130 (BOL) and 8/11/1943, *Esterhuysen* 9177 (BOL); Great Winterhoek Mt. 1600—1800 m (-AA), 27/1/1957, Esterhuysen 20013 (BOL): Hex River Mts. Sentinel Peak Cliffs on Southside 1800 m (-AD/CB), 15/12/1957, Esterhuysen 27436 (BOL).

Erica setociliata is named from the long ciliations on the sepals and, to a lesser extent, on the leaves. From its generally diffuse habit which, however, varies to some extent in different localities owing to the amount of shade, it seems properly to take its place in the section *Ceramia*. It can, however, be said to be calycine or subcalycine as defined in Fl. Cap. 4: 5 (1909) in relation to the genus *Erica* but it does not fit into the sub-genus *Platystoma*. It does not appear to be closely related to any other species in *Ceramia* and thus, in the author's opinion, merits specific rank.

Erica insolitanthera H. A. Baker, sp. nov., (Ericaceae-Ericoideae) Hermes.

Fruticulus erectus lignosus ad basim ramificans; in omnes partes, praeter androecium, viscidus; ad c. 30 cm altus. *Rami* atque penduculi, canohispidi aliquot setis glanduliferis immixtis, glabrescentes et cicatricatibus foliorum delapsorum noti. *Folia* pro parte maxima 4-nata, interdum irregulariter verticillata, 2—6 mm longa, late patentia ad squarrosa, supra incurva, imbricata, late lineata ad oblonga, acuta, sulcata, crassa, juniora sparsim canopubescentes, aliquot glandibus immixtis, glandibus albis ciliata. *Flores* axillares, solitarii, versus apicices ramorum fasciculati, pedunculati, 7—9 mm longi, atrorubri; bracteae, 2 medianae, 1 basilis, c. 2 mm longae, lineares, apicibus carinatis, niveae. *Sepala* c. 4 mm longa, ovatolanceolata apicibus sulcatocarinatis, recurvis, glabra, glandulosociliata, virella, vel rubra. *Corolla* varians, 6—9 mm longa ovatiurceolata, varie inflata, fauce constricta, sparsim et subtiliter pubescens, rosea; lobi 2 mm longi, leviter recurvati, subobtusi, brunnescens. *Filamenta* ligulata gracilia; antherae inclusae, 1.2 mm longae, terminales, bipartitae, oblongae, supra obtusis, cellulis decrescens, infra aristas terminales emittens filamento adnatescens per 0,3 mm, tandem libris et effusis c. 0,7 mm; poro fere dimidio pars lobi. *Ovarium* ovoideum glabrum; stylo exserto; stigmate capitellato.

Erect, woody shrublet branching from the base; viscid in all parts except the androecium; about 30 cm high. *Branches*, like the peduncles, white-hispid with some gland-tipped hairs intermixed, becoming glabrous and scarred by the persistent leaf cushions. *Leaves* mostly 4-nate but sometimes irregularly whorled, 2—6 mm long, wide-spreading to squarrose, incurved above, imbricate, broad-linear to oblong, acute, sulcate, thick, the younger sparsely white-pubescent with some glands admixed, white gland-ciliate. *Flowers* solitary in the leaf axils and forming rather dense clusters at the ends of the branches; peduncles 7—9 mm long, dark red; bracts, two median, one basal, about 2 mm
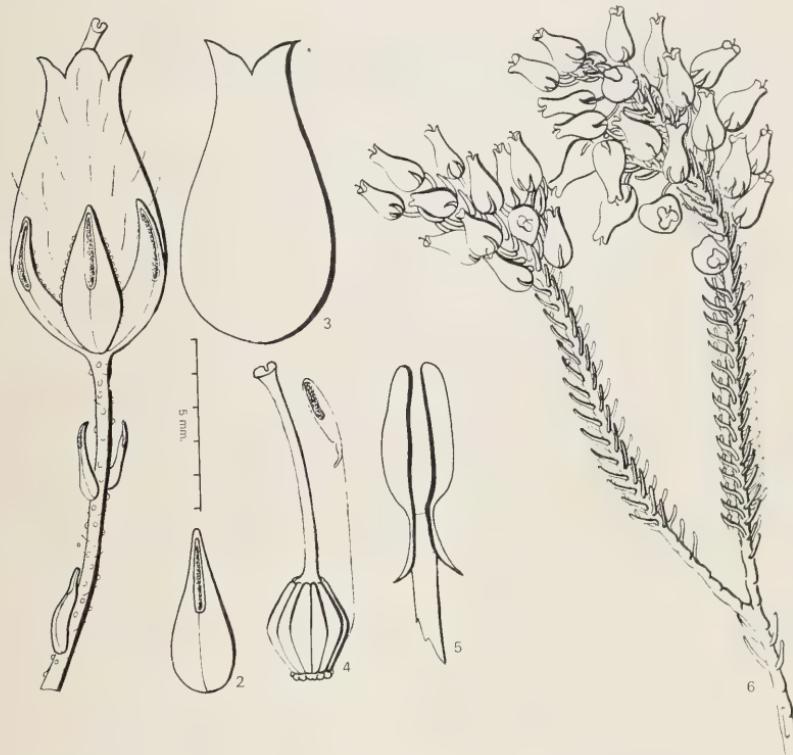
Fig. 1.
E. insolitanthera H. A. Baker
1. Flower, 2. Sepal, 3. Corolla, 4. Androecium and stamen, 5. Anther, back view, at twice the scale. 6. Sprig, approx. life size. del. C. de Moor.

long, linear, keel-tipped, whitish. Sepals about 4 mm long, ovate-lanceolate, keeled and sulcate-keel-tipped with the upper margins recurved, glabrous, gland-ciliate, greenish to red. *Corolla* variable in shape and length, 6—9 mm long, ovate-urceolate, variously inflated, narrowed at the throat, sparsely and finely pubescent, rose; lobes 2 mm long, slightly recurved, subobtuse, becoming brown. *Filaments* ligulate, slender; anthers included, 1,2 mm long, terminal, bipartite, oblong, obtuse above, cells narrowed below into subulate awns which become adnate to the filament for about 3 mm and finally spreading freely for about 0,7 mm; pore about half the length of the cell. *Ovary* ovoid, glabrous; style exserted; stigma capitellate.

CAPE—3419 (Caledon): Riviersonderend Mts. amongst rocks on low cliff between Skilpadkop and Junction Peak (—BA), c. 1220 m, Feb. 1971, *Esterhuysen* 32568 (BOL, holotype); Skilpadkop area amongst rocks on summit c. 1220 m, Jan. 1953, *Esterhuysen* 21010 (BOL); Riviersonderend Mts., Paardekop Peak Jan. 1940, *Stokoe* 7347 (BOL, SAM, NBG).

This taxon is chiefly remarkable for being more or less glandular-viscid in all parts except the androecium and for having rather remarkable anthers, as described. It does not appear to be closely related to any other species described in the section *Hermes* but rightly belongs there according to the definition of that section.

ACKNOWLEDGEMENT

A NEW SPECIES OF *HAWORTHIA* (LILIACEAE)

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ABSTRACT

A new species of *Haworthia* is described from the Robertson Karoo. This species, *H. pubescens* Bayer, is found in a restricted area south of Worcester, and its relation to other species in the area is discussed.

UITTREKSEL

'N NUWE SOORT *HAWORTHIA* (LILIACEAE).

'n Nuwe soort *Haworthia* vanaf die Robertson Karoo word beskryf. Hierdie soort, *H. pubescens* Bayer, word in 'n beperkte area suid van Worcester gevind, en die verwantskap met ander soorte in die area word hier bespreek.

INTRODUCTION

Von Poellnitz described several varieties of *Haworthia schuldtiana* V. Poelln., mostly from the Robertson Karoo. During investigation into field populations it was found that the described species and varieties bear little relation to the situation in the field. It seems certain that there are several discrete population groups as well as anomalies, and that these should be recognised as such. The object of this paper is to describe a hitherto unnamed element in this complex and discuss its affinities with other species in the area.

INVESTIGATION

From a fairly intensive coverage of the Robertson Karoo it is clear that the small, dark-green, rough-surfaced *Haworthia* associated with *H. schuldtiana* V. Poelln. are common south and east of Langvlei between Robertson and Worcester. The type of the species is recorded from McGregor, and this characristic form is found at several localities near there, as well as westward to Trappieskraalkloof south-east of Worcester, and eastward to the Stormsvlei Pass.

H. maraissii V. Poelln. at Stormsvlei may perhaps best be recognized as an element (subspecies?) in this complex. At Robertson, and specifically Muiskraalkop (the type locality for *H. shuldtiana* var. *robertsonensis* V. Poelln. fide G. J. Payne), there is an assemblage of forms which may best be regarded as anomalous. From here one moves eastward into the *H. guttata* Uitew. complex near Bonnievale, north-westward to a complex at the farm Dublin, including
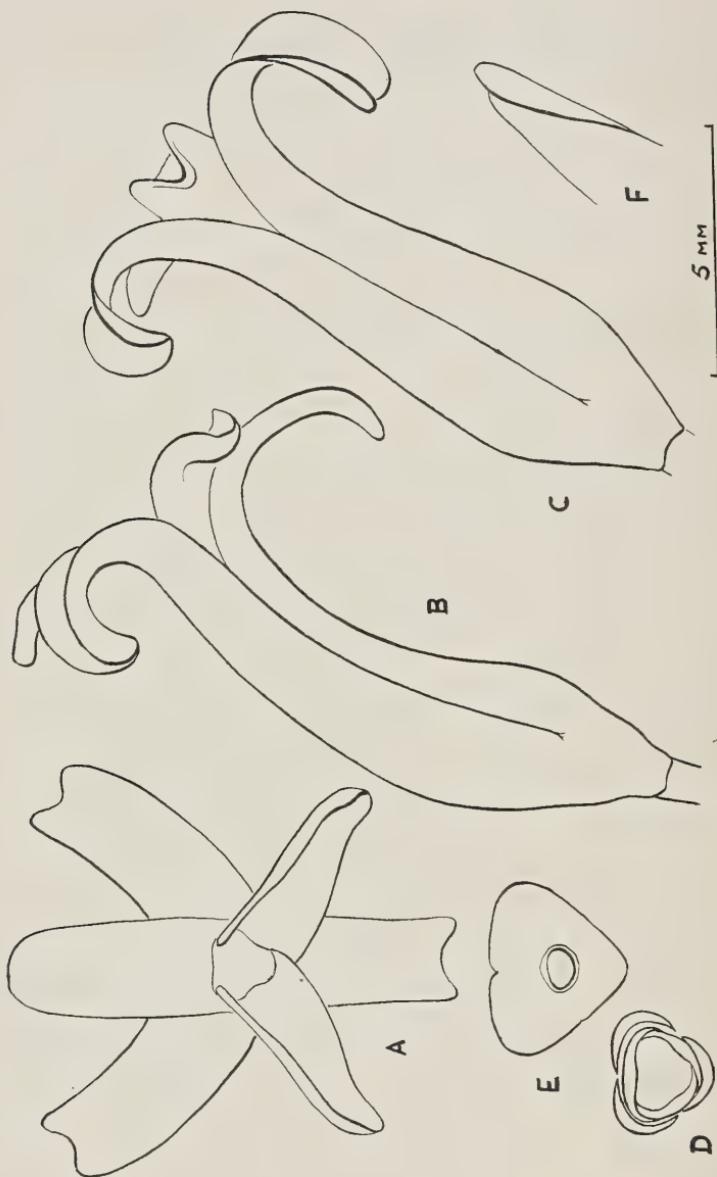
Fig. 1.

H. pubescens Bayer sp. nov. Diagram of flower—(*a*) flower face, (*b*) profile, (*c*) top view, (*d*) cross section, (*e*) view of perigon, (*f*) upper-outer segment incurved as in *H. schuldtiana* V. Poelln.

anomalies, and then also eastward to populations at Ashton, Cogmanskloof, Montagu and Barrydale. The locality, appearance of the plants and known variation within the Robertson Karoo, suggest that *H. schuldtiana* var. *major* Smith is not intimately involved here and should be accorded species status. Similarly *H. schuldtiana* var. *simplicior* V. Poelln. at Malgas (correctly Napky,
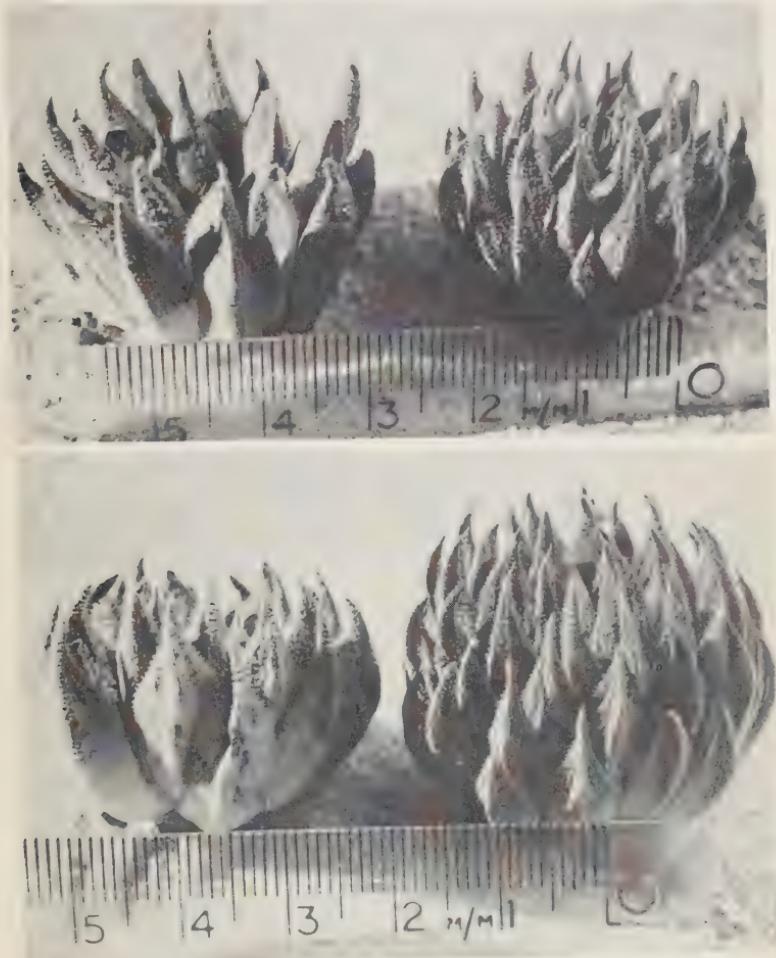
Figs. 2 and 3.
H. pubescens Bayer sp. nov. KG 112/70, south of Worcester.

south-west of Swellendam) is apparently also disjunct and has associated elements which extend westward to Bredasdorp. Several of Von Poellnitz' varieties cannot yet be located in terms of field populations (including *H. triebneriana* V. Poelln. var. *nitida* V. Poelln.) and it is not certain whether or not they are merely variants within populations from which elements may already have been named, e.g. *H. schuldtiana* var. *minor* V. Poelln. from McGregor is a normal variant of the species. It should be noted though, that *H. schuldtiana* var. *maculata* V. Poelln. has since been accorded species status (Bayer, ms.) and not in direct association with *H. schuldtiana*. The involvement of *H. guttata* and *H. notabilis* V. Poelln. cannot yet be rationally discussed and it is also not certain where *H. sublimpidula* V. Poelln. has its affinities.

The small dark *Haworthia* first recorded by Mr. F. J. Stayner south-east of Worcester, was initially thought to be a variant of *H. schuldtiana*. However, this population is clearly discrete from those typical of the species and the other known variants and is here named *H. pubescens* Bayer spec. nov. There are two populations at Oliva, Robertson, which may prove to be identifiable with this new species, perhaps forming a tenuous association with the anomalous population at Muiskraalkop. Other factors which lend credence to the species status of Mr. Stayner's plants are firstly the flowering time which is late November-December, unlike *H. schuldtiana* and its nearer associates (including *H. notabilis* and *H. guttata*) which flower March-April; and secondly flower structure. Although floral morphology and its variation is not yet well understood in Haworthia, it is clear that *H. pubescens* shows several characters

FIG. 4.
H. schuldtiana V. Poelln. KG 212/70, McGregor.

separating it from *H. schuldtiana*. The flower bud in *H. pubescens* is rather narrowly elongate and regularly biarcuate (albeit only partially) whereas in *H. schuldtiana* the bud is abbreviated and only the extreme tip is upcurved. The dorso-ventral flattening and distinct bifidity of the bud-tip in *H. pubescens* results in a flared arrangement of the segments as is found in *H. herbacea* (Mill.) Stearn, *H. reticulata* (Haw.) Duval and *H. maculata* (V. Poelln.) Bayer (ms.). The incurvature of the upper margin of the inner lower segments is comparable with that in the latter species. Another notable feature is that the upper, outer lobes are widely open, whereas in *H. notabilis*, *H. guttata* and *H. schuldtiana* the outer terminal margins of these segments are inclined forward and inward. This character is also observed in the eastern forms of *H. reticulata* at Bonnievale. The accompanying illustration shows this difference, but too much attention should not be paid to points in the diagram such as degree of recurvature of the segments, shape of the perigon and shape of the flower base. It has been repeatedly observed that these can be highly variable within quite wide limits. Age of the flower alone also effects the facies of the flower as it does also the dimensions of the pedicel, ovary, style and stamens.

Vegetatively, *H. pubescens* has the leaf shape and arrangement of the *H. herbacea* segregates, while the colour and nature of the leaf excrescences are more like these in *H. schuldtiana* and *H. guttata*. *H. pubescens* is found growing very near to *H. herbacea* but no hybrids have been seen. The locality is on a sandstone ridge, rather unique in the area from both geological and botanical viewpoints.

It is concluded that *H. pubescens* is a valid new species with probable affinities in both the *H. schuldtiana* and *H. herbacea* complexes, and is described as follows:—

Haworthia pubescens M. B. Bayer sp. nov. (Liliaceae—Aloineae).
Foliorum rosula acaulescens, 2,5—4 cm in diam., circa 50 folia. *Caulis* crassus, carne albis, $\frac{1}{2}$ diam. rosulae. *Radices* crassae, firmae, albae, carnosae, nonfibrosae. *Folia* erecta, expansa, apices versus incurvati, usque 30 mm longa, 8 mm lata, 4 mm crassa, ovata lanceolata acuminata, aristata cum seta usque 2 mm longa, atroviridia incana, plana lineis indistinctae; *supra* plana ad concava ad bases, convexa turgida versus apices, leviter ad modice muricata, tuberculia saepe setifera; *subtus* convexa, carinata ab prope bases, plerumque altera carinata contiguus vel ab proper margines, modice ad densa muricata, tuberculia plerumque setifera, spinae carinales non seriatae; *margines* subacutae, spiniferae; *spinae* albae, usque 0,5 mm longae, 0,2—0,3 mm distans.
Pedunculus simplex, 1 mm diam., 10—15 mm longus, racemo incluso, subroseus-fuscus; *racemus* 5—8 mm longus, flores 8—12, 1—2 apertus; *pedicelli* 1—3 mm longi, <1 mm diam.; *bracteae steriles* 8—15, 4—7 longae; *bracteae fertiles* 5—7,5 mm longae. *Perianthium* album, rotundata triangularis ad basis, 13—14

mm longum; *segmentia* regularia stellata patentia, supera externa leviter plicata, inferna interiora margines superae incurvae ad apices; *gemmae* leviter biarcuatae, angustatae elongatae, bifidae ad apices. *Florescentia* sero Nov.–Dec.

Rosette acaulescent, 2,5—4 mm diam., upto 50 leaves. *Stem* thick, white-fleshed, $\frac{1}{2}$ diam. of rosette, seldom elongate, seldom proliferous. *Roots* thick, firm, white-fleshed, non-fibrous. *Leaves* erect, spreading, incurved at tips, firm, upto 30 mm long, 8 mm broad, 4 mm thick, ovate-lanceolate acuminate, aristate with setiferous bristle upto 2 mm long, very dark-green with frosted appearance, longitudinal lines sometimes distinct; *face* flat to concave at base, convex turgid toward middle and tip; slightly to moderately muricate, excrescences frequently spined; *back* convex, keeled from near base, moderately to densely muricate, excrescences frequently spined, frequently with a second keel near middle or toward margins, spines on keel not in clearly defined rows; *margins* sub-acute, spined; *spines* white, upto 0,5 mm long, 0,2—0,3 mm apart. *Peduncle* simple 1 mm diam., 10—15 mm long including raceme, pinkish-brown; *raceme* 5—8 mm long, 8—10 flowers with 1—2 open; *pedicels* 1—3 mm long, 1 mm diam.; *sterile bracts* 8—15, 4—7 mm long; *fertile bracts* 5—7,5 mm long. *Perianth* white, rounded triangular at base, 13—14 mm long; *segments* regular stellate, outer segments slightly plicate at tips, inner lower segments with upper margins incurved to tips, nerves pinkish-brown; *buds* partly biarcuate, narrowly elongate, bifid at tips. *Flowering* late Nov.–Dec.

Type: Sandberg hills, 12 km S.S.E. of Worcester, *Bayer* KG 112/70 holotype NBG.

H. pubescens resembles *H. schuldtiana* in size, colour and nature of surface excrescences but is more densely muricate and pubescent. It is nearer to *H. herbacea*, *H. reticulata* and *H. maculata* as regards leaf shape and arrangement, and also in floral structure and flowering time. The biarcuate bud and associated flare of the tips of the upper outer perianth segments appears most markedly in these species in the Robertson Karoo, and also in the *H. mirabilis* (including the *H. triebneriana* V. Poelln. varieties) complex of the South-Western Districts.

INTEGRATED EXPERIMENTAL ECOLOGY, ed. by Heinz Ellenberg, with pp. 214. London: Chapman & Hall Ltd. Berlin, Heidelberg, New York: Springer-Verlag, 1970. £6.70 (U.K.).

This is Volume 2 in the series Ecological Studies, the first being an Analysis of Temperate Forest Ecosystems which the reviewer unfortunately has not yet read.

It would seem from reports that the earlier work is of more general interest and likely to enjoy greater readership. Which might be a pity as this volume is very much a methodological treatise concerned with co-operative research in progress within the framework of the International Biological Programme: it has therefore a validity which a collection of articles by an international panel—no matter how distinguished—cannot possibly achieve.

The Solling Project of the German Research Association (Solling is a forest and grassland area near Göttingen) commenced in 1967 and is to be completed in 1972. Nevertheless this is more than a mere interim report, being an invaluable practical guide for any research group studying ecosystems.

Integrated projects of this nature have been accorded high priority by IBP participants and this pilot scheme is no exception, being an exemplary example of experimental environmental research. The IBP in its present form ceases to function after 1972 but the urgent necessity for evaluation of the human environment will continue as "Our very existence depends upon an exact study": the research worker and student at all levels will learn from this volume how to acquire the necessary quantitative data.

In 214 pages, a German team under the co-ordinating director (and editor) Professor Ellenberg have produced a publication on the grand scale. Substantially bound, well-documented, a plethora of tables and figures well-integrated with the text, photographs perhaps no more than adequate, this coverage of four years work would put many completed research publications to shame—those of the F.A.O. immediately spring to mind.

References are cited at the end of each chapter and obviously many are of outstanding quality; it is a pity therefore that they have been published in journals which are either relatively obscure or are difficult to obtain in South Africa. There is frequent alternation of type setting and paper quality but this does not materially affect the presentation.

The work is in four parts and, considering the mammoth size of the project team and the number of contributors, is surprisingly consistent. There is an Introductory Survey by Ellenberg; Part 1 is concerned with Primary Production; Part 2 with Secondary Production; Part 3: Environmental Conditions and Part 4: Range of Validity of the Results. There is a Subject Index. As several research projects have still to be integrated in the final synthesis, Part 4 suffers rather more than the others from lack of cohesion. There are other gaps too, but there must have been a very high degree of cooperation at all levels to achieve such an effective synthesis of data in so many fields.

Though perhaps not so suitable for the layman, all who are interested in the environment of man can derive benefit from it. The methods and data presented will aid other countries participating in IBP projects and South African students will certainly gain from the experience recorded.

Astonishingly little is known about the functioning of terrestrial ecosystems and the impact of man upon them: in Southern Africa the need for research is not only desirable it is urgent. This book illustrates that unless we put our house in order, life will be impossible—and the expectation of it highly improbable.

O. KERFOOT

NEW RESEARCH IN PLANT ANATOMY, ed. by N. K. B. Robson, D. F. Cutler, and M. Gregory. Supplement 1 to the Botanical Journal of the Linnean Society Vol. 63, with xii + 250 pp., numerous micrographs and line drawings. London: Academic Press, 1970. £6.

This volume consists of twenty original research papers on plant anatomy, some of which were read at a symposium arranged in 1970 by the Plant Anatomy Group of the Linnean Society, in honour of Dr. C. R. Metcalfe, after his retirement from the post of Keeper of the

Jodrell Laboratory, Royal Botanic Gardens, Kew. A high proportion of the contributors have at some time worked at the Jodrell Laboratory during his tenure of office there.

The contributions are of a high standard and show the wide range of anatomical subjects which are being investigated all over the world.

Several papers give the classical approach to plant anatomy: P. B. Tomlinson gives the first unequivocal demonstration of true dichotomy in a monocotyledon, *Flagellaria*, involving the division of the apical meristem into two more or less equal halves; this is quite distinct from the so-called dichotomous branching found in many woody monocotyledons. Flora Scott and B. Bystrom studied in *Hibiscus esculentus* a generally ignored subject namely the structure of mucilage-producing idioblasts. Continuing his studies on vessel anatomy and specialisation, V. I. Cheadle deals with the vessels in the monocotyledons Pontederiaceae, Ruscaceae, Smilacaceae, and Trilliaceae. D. R. Kaplan shows that the nodal appendages of the "rachisleaves" of two Umbelliferous genera are equivalent to reduced pinnae of a compound leaf. R. A. Howard reviews the nodal structure of stems, giving special attention to the "split-lateral" leaf traces found in eight families.

In two contributions the application of the electron microscope is shown: A. Fahn et al. studied the ultrastructure of the nectar-secreting hairs of *Lonicera japonica*, attempting also to find the cell organelles responsible for nectar secretion. The use of the scanning electron microscope for the study of wood is illustrated by G. W. D. Findlay and J. F. Levy.

Several more papers on wood structure are included: P. Greguss deals with the structure of xylem rays in the Araucariaceae, and L. Chalk with the length of fibres and vessel members in early and late wood of *Fraxinus* species. S. Carlquist shows that the sections of the genus *Euphorbia*, from Hawaii, the Macaronesian Islands, and Africa respectively, differ in wood structure and concludes that in these groups woodiness developed independently from herbaceous ancestors.

No less than eight papers deal with comparative anatomy and systematics: N. H. Brittan gives a preliminary survey of the stem and leaf anatomy of 26 species of *Thysanotus* and attempts to correlate anatomical characters with morphological groupings. C. A. Stace shows that the British species of a subgenus of *Juncus* can be distinguished by anatomical features. W. R. Philipson finds that the floral anatomy of members of the Araliaceae confirms the close relationship of this family to Umbelliferae. An anatomical study by E. A. Ayensu of the vegetative organs of two yams (*Dioscorea rotundata* and *D. cayenensis*) which are not easily separated on exomorphic grounds shows that they are indeed two species. I. Kukkonen shows on anatomical grounds that *Carex camptoglochin*, whose distinction from *C. microglochin* was uncertain, is a distinct species. Margaret Stant gives an anatomical analysis of the rare monocotyledonous saprophyte *Petrosavia* and assesses its relationship with other groups. W. L. Stern et al. find considerable similarities in the anatomical characters of species of *Ribes* and conclude that it cannot be validly separated on anatomical grounds into two taxa.

Two papers deal with seed anatomy: K. A. Chowdhury and G. M. Buth were able to prepare a key based on seed morphology and seed coat anatomy for ten genera of the Papilionatae occurring in India; and J. G. Vaughan deals with the anatomical structure of seeds used in the animal feed industry.

The only contribution from a non-anatomist is from H. T. Clifford, who gives a resumé of his numerical taxonomic work on monocotyledonous families and a more detailed analysis of three families, by employing reproductive and anatomical characters.

The book concludes with a list of Dr. Metcalfe's publications.

The numerous micrographs and other illustrations are excellent and the standard of production of the volume is high. A detailed index is supplied.

The book is mainly for the plant anatomist and will be a very welcome addition to his library. The taxonomist will also be interested and several articles may be useful to the lecturer who teaches advanced plant anatomy.

M. P. DE VOS

INSTRUCTIONS TO CONTRIBUTORS
TO THE
JOURNAL OF SOUTH AFRICAN BOTANY

This Journal provides a medium for the publication of the results of botanical research primarily on the flora of Southern Africa, whether systematic, morphological, ecological or otherwise and whether carried out in South Africa or elsewhere. Papers on botanical subjects of special interest and application in South Africa may be included.

Contributions must be original and should not be translations of previously published papers.

Papers must be submitted in final, corrected form. They are accepted for publication on the recommendation of the Editorial Committee.

Authors may be charged expenses for corrections if alterations are excessive.

COPY

Papers should be type-written, double spaced throughout on one side of the paper and with margins of at least 3 cm (1 inch). Footnotes and elaborate tables should be avoided. Latin binomials should be underlined once to indicate italics. All other marking of copy should be left to the Editor. The original, plus at least one carbon copy, must be submitted.

GENERAL LAY-OUT

Each paper should be headed with a concise informative **title** in capitals with the author's name below. This should be followed by the name of the institution, where the work was carried out, underlined and placed within brackets.

A concisely written **abstract** in English and Afrikaans, of not more than 200 words, should precede the text.

The subject matter should be divided into sections under short appropriate **headings** such as: INTRODUCTION, MATERIAL AND METHODS, RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGMENTS, etc.

Tables and **illustrations** should be on separate sheets. **Figures** and **graphs** should be in Indian ink on white card or Bristol board. Lettering for figures can be inserted by the printers in which case authors should indicate the desired lettering on the original figure lightly in pencil. The maximum dimensions available for figures are 18 cm × 12 cm ($7'' \times 4\frac{1}{2}''$). Line drawings for blocks should be at least twice the size they will be when reduced for publication. All figures should be supplied with a scale. The most suitable method of indicating magnification is a scale line (in metric units) incorporated in the figure. Photographs for half-tone reproductions should be on glossy paper, clearly marked on the reverse side (in pencil) to indicate the top. Line drawings and half-tone illustrations are termed figures and should be numbered consecutively. Captions for figures should be typed on a separate sheet of paper.

TAXONOMIC PAPERS

Authors must adhere to the International Rules of Botanical Nomenclature. **Abbreviations** and **herbaria** must be cited in accordance with the most recent edition of Index Herbariorum, Pt 1 (The Herbaria of the World, 5th ed., 1964). When **new species** are described, the exact location of type material must be indicated. When proposing **new combinations** the full citation of the basionym is required. **Indented keys** with numbered couplets are preferred when dealing with a small number of taxa. **Bracket keys** should be used when dealing with a large number of taxa. When citing **synonyms** they should be arranged chronologically into groups of nomenclatural synonyms and these should be

arranged chronologically by basionyms. Whenever possible, the types of the basionyms should be cited, e.g.:

Bequaertiodendron magalismontanum (Sond.) Heine & J. H. Hemsley in Kew Bull. **1960**: 307 (1960).
Chrysophyllum magalismontanum Sond. in Linnaea **23**: 72 (1850). Type: Magaliesberg, *Zeyher,* 1849 (S, holo; BOL!, SAM!).
Zeyherella magalismontana (Sond.) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).
Pouteria magalismontana (Sond.) A. Meeuse in Bothalia **7**: 335 (1960).
Chrysophyllum argyrophyllum Hiern, Cat. Afr. Pl. Welw. **3**: 641 (1898). Syntypes: Angola, *Welwitsch* 4827, 4828, 4829 (BM!).
Boivinella argyrophylla (Hiern) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).
Chrysophyllum wilmsii Engl., Mon. Sapot. Afr.: 47 t. 16 (1904). Type: Transvaal *Wilms* 1812 (B†, holo.; K!).
Boivinella wilmsii (Engl.) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).

CITATION OF SPECIMENS

In the interests of uniformity contributors are requested to follow the recommendations of the Botanical Research Institute, Pretoria (Technical note: Gen. 4, Oct., 1967) by citing specimens according to the one degree grid system. Distribution data are given separately for each province and are arranged in the following sequences: South West Africa, Botswana, Transvaal, Orange Free State, Swaziland, Natal, Lesotho, Cape. Within each province degree squares are listed in numerical sequence, i.e., from west to east and from north to south. Whenever possible locality records should be given to within a quarter degree square. The collectors' names and numbers are underlined (printed in italics) to avoid confusion with the numbers of the degree squares, e.g.: NATAL—2829 (Harrismith): Cathedral Peak Forest Station (-CC), *Killick* 5127 (PRE); . . . CAPE—3418 (Simonstown): Hottentots Holland mountains, Somerset Sneeukop (-BB), Nov., *Stokoe s.n.* sub. SAM *56390* (SAM).

REFERENCES

These should begiven in the text as follows: Jones (1968) or (Jones, 1968) or, where reference to a specific page is required, Jones (1968:57) or (Jones, 1968:57). **Literature cited** should be arranged alphabetically by surnames, chronologically within each name, with suffixes a, b, etc., to the year for more than one paper by the same author in that year Titles of **periodicals** must be abbreviated according to the *World List of Scientific Periodicals,* 4th ed., London: Butterworth or when unable to trace the title in this list (as will be the case in taxonomic papers where abbreviations of 18th and 19th century periodicals art required) the abbreviations given in *Botanico-Periodicum-Huntianum,* Pittsburgh: Hune Botanical Library, 1968, should be followed. Periodical titles should be underlined once (for italics). If an author is unable to determine the correct abbreviation of a journal title he is advised to type it out in full and leave its abbreviation to the Editor. Titles of **books** should be underlined and given in full, together with the place of publication, name of the publisher and an indication of the edition if ōther than the first; e.g.:

Davis, P. H. and Heywood, V. H., 1963. *Principles of Angiosperm Taxonomy.* Edinburgh and London: Oliver and Boyd.
Riley, H. P., 1960. Chromosome numbers in the genus *Haworthia. Jl S. Afr. Bot.* **26**: 139—148.

CHARACTERIZATION OF GERMINATION INHIBITORS IN SEED EXTRACTS OF FOUR SOUTH AFRICAN SPECIES OF PROTEACEAE*

J. van Staden and N. A. C. Brown

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Abstract

Water extracts of the seed coat and embryo of *Protea compacta, P. barbigera, Leucospermum cordifolium* and *Leucadendron daphnoides* were separated chromatographically in *n*-butanol:ammonia:water and ethyl acetate:ammonia. The lettuce seed bioassays used for the detection of germination inhibitors in the extracts showed that the major inhibitor present had an R_f value similar to coumarin. A second inhibitor, present in some extracts, had an R_f value similar to ABA. Ether extracts and ethyl acetate extracts separated in *n*-butanol:ammonia: water confirmed the findings obtained from water extracts. The lettuce seed bioassays used for the detection of germination promotors gave no indication of their presence in ether extracts.

A UV spectrophotometric analysis of the ethyl acetate extracts of *Protea compacta* showed that the major inhibitor, with the same R_f value as coumarin, had the same UV absorbance peak as the coumarin standard. The inhibitor with the same R_f value as ABA was shown to have a different absorbance peak to the ABA standard.

Uittreksel

KARAKTERISERING VAN ONTKIEMINGSTREMSTOWWE IN DIE EKSTRAKTE VAN SAAD VAN VIER SUID AFRIKAANSE PROTEACEAE.
Waterekstrakte van die saadhuid en embrio van *Protea compacta, P. barbigera, Leucospermum cordifolium* en *Leucadendron daphnoides* is met behulp van *n*-butanol:ammonia:water en etielasetaat:ammonia chromatografies geskei. Die slaaisaadbiotoetse wat gebruik is, toon dat die hoofstremstof teenwoordig in dié ekstrakte 'n R_f-waarde het wat ooreenstem met die van koemarien. 'n Tweede stremstof, wat in sekere ekstrakte aanwesig is, het 'n R_f-waarde in ooreenstemming met dié van absissiensuur (ABS). Eterekstrakte en etielasetaatekstrakte wat met behulp van *n*-butanol:ammonia:water geskei is, bevestig die bevindings wat verkry is deur middel van waterekstrahering. Die slaaisaadbiotoetse wat aangewend is om 'n aanduiding van enige ontkiemingsnelstowwe te gee, was negatief.

Spectrofotometriese analise van die etielasetaatekstraksies van *Protea compacta* toon dat die hoofstremstof, naamlik dié met dieselfde R_f-waarde as koemarien, ook dieselfde UV absorpsiepiek as die koemarien-standaard het. Die stremstof met dieselfde R_f-waarde as ABS het egter 'n absorpsiepiek gehad wat verskil met dié van die ABS-standaard.

Introduction

In an earlier investigation (Brown and Van Staden, 1971) it was shown that the aqueous extracts (diffusates) of the seed coats and embryos of *Protea compacta, P. barbigera, Leucospermum cordifolium* and *Leucadendron daph-*

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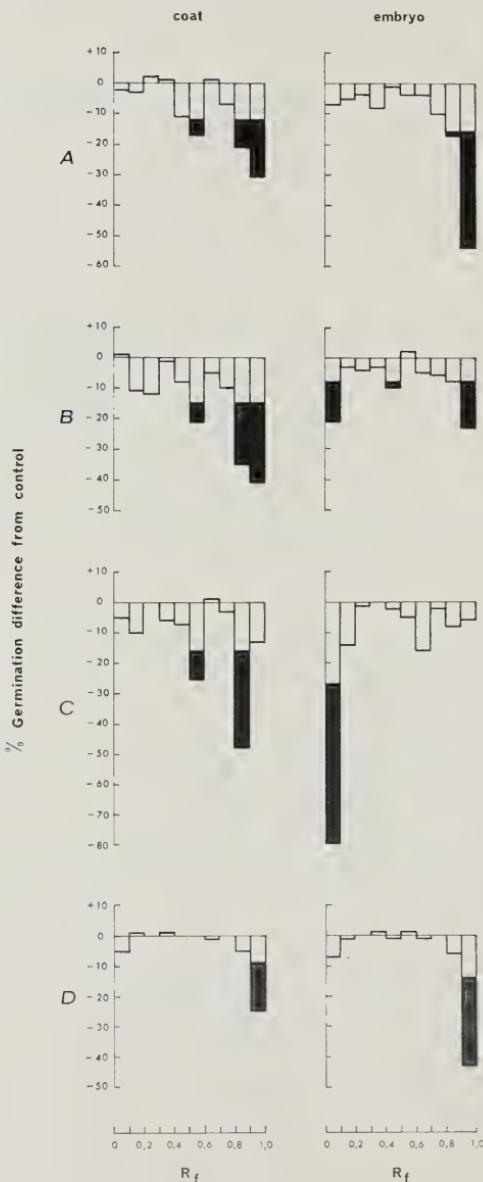
FIG. 1.

noides inhibited either seed germination or subsequent root growth of seedlings of lettuce and water cress. It was shown that this inhibition could not be accounted for on the basis of osmotic pressure alone. Chromatographic separation of the seed coat and embryo extracts of all species showed a band of inhibition corresponding to R_f values of 0,9—1,0. These results were compared with the inhibitory effects of two widely occurring germination inhibitors, viz. coumarin and ABA. Coumarin was reported by Evenari (1949; 1961) and Wareing (1965) to be of wide occurrence in plant tissue and to be one of the most potent of the naturally occurring germination inhibitors. Since its discovery by Okhuma, Smith, Lyon and Addicott (1963), ABA has been found to be associated with the dormancy of seed of a number of species, e.g. peach (Lipe and Crane, 1966), rice (Dey and Sircar, 1968), and apple (Rudnicki, 1969). Previous work indicated that, after separation in *iso*-propanol:ammonia:water, the coumarin and ABA standards could not be distinguished from one another and from the seed extracts when compared on the basis of the inhibition produced in the bioassays.

In this paper further chromatographic techniques were used in an attempt to characterize the inhibitors occurring in the seed extracts. Special attention was given to a comparison of the properties of these inhibitors with those of coumarin and ABA to determine whether the latter inhibitors were present in the seeds.

MATERIAL AND METHODS

Seed used in all experiments was purchased from the Department of Forestry, Pretoria.

Techniques for extraction of seed.

(*a*) *Water extract.* The technique for obtaining water extracts of the seed coats and embryos (including the cotyledons) was basically the same as described earlier (Brown and Van Staden, 1971). The only modification was that the leachate was concentrated to dryness under reduced pressure at 40°C. The residue was taken up in one ml distilled water and 500 µl of this was immediately strip-loaded on to a chromatogram.

(*b*) *Ether extract.* The method of extraction was based on that of Eagles and Wareing (1964) and Irving and Lanphear (1968). Fifteen grams of seed was separated into coats and embryos; each was homogenized in a blendor at room temperature in 80°₀ aqueous methanol. The fractions were kept overnight in a refrigerator and then filtered through Whatman No. 42 filter paper. The

FIG. 1.
A comparison of the effects of water extracts of seed coats and embryos on germination of "Grand Rapids" lettuce seed in light.
A = *Protea compacta;*   B = *P. barbigera;*   C = *Leucospermum cordifolium;*
D = *Leucadendron daphnoides*
The solvent was *n*-butanol:ammonia:water. The shaded areas represent differences significant at 1% level.
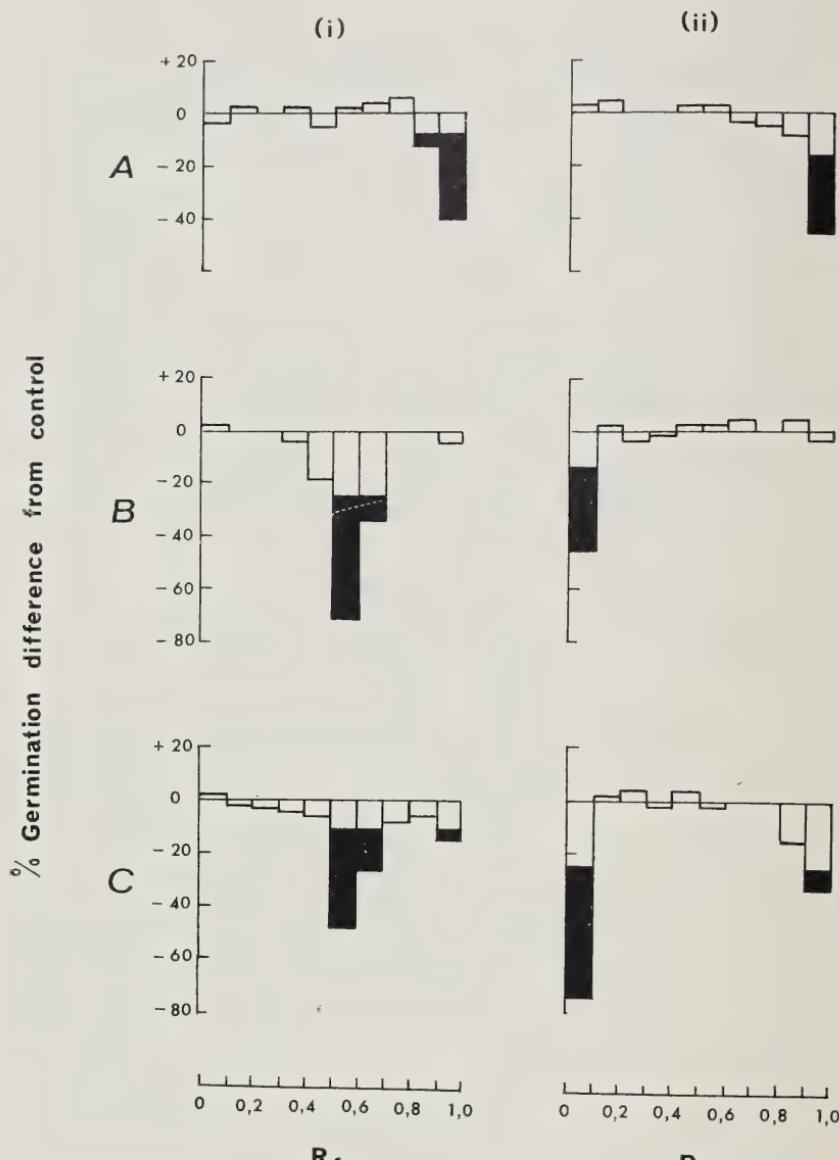
FIG. 2.

fractions were concentrated at 30°C under reduced pressure in order to remove the methanol. The aqueous fraction was acidified to pH 2,0 with 5% H_2SO_4 and then extracted six times with 50 ml ether. The ether fraction was reduced to dryness under reduced pressure at 40°C. The residue was dissolved in six ml dry ether, three ml of which was loaded immediately on each of two chromatograms. One chromatogram was used in a lettuce seed germination bioassay in the light and the other for a similar bioassay, but in the dark.

(c) *Ethyl acetate extract.* The extraction technique used was similar to that used by Davis, Heinz and Addicott (1968) for the extraction of ABA. Fifteen grams seed was separated into coats and embryos. Each was homogenized in 100 ml 80% acetone, kept in a refrigerator overnight and then filtered through Whatman No. 42 filter paper. The extracts were then evaporated to an aqueous residue, acidified to pH 2 with HCl and extracted twice with equal amounts of ethyl acetate. The acidic ethyl acetate was combined and extracted twice with equal amounts 5% $NaHCO_3$. The pH of the combined sodium bicarbonate fractions was adjusted to two and it was extracted twice with equal amounts of ethyl acetate. After being reduced to dryness the residue was taken up in 4 ml ethyl acetate and immediately strip-loaded on to chromatograms.

Chromatography

All extracts were separated at room temperature using descending paper chromatography. The concentrated extracts and the standards were strip-loaded on Whatmans No. 1 chromatography paper. The chromatograms were equilibrated for four hours prior to development. After the solvent front had travelled about 40 cm, the chromatograms were dried and cut into ten equal transverse strips. The biological activity of each strip was determined in the lettuce seed germination bioassay.

The water extracts were sparated in two solvent systems viz. (i) *n*-butanol: ammonia:water (100:3:18 v/v), and (ii) the organic phase of ethyl acetate: 2N ammonia (1:1 v/v).

Bioassays

When only the inhibitor activity of extracts was investigated the bioassay was done in the light. When both inhibitor and promotor activity was investigated the bioassay was carried out in the dark. All experiments were repeated at least twice.

FIG. 2.
A comparison of the effects of ABA and coumarin on the germination of "Grand Rapids" lettuce seed in light. The solvents were (i) *n*-butanol:ammonia:water and (ii) ethylacetate: ammonia.
A = Coumarin   B = ABA   C = Coumarin + ABA
The shaded areas represent differences significant at 1% level.

coat   embryo

% Germination difference from control

R_f R_f
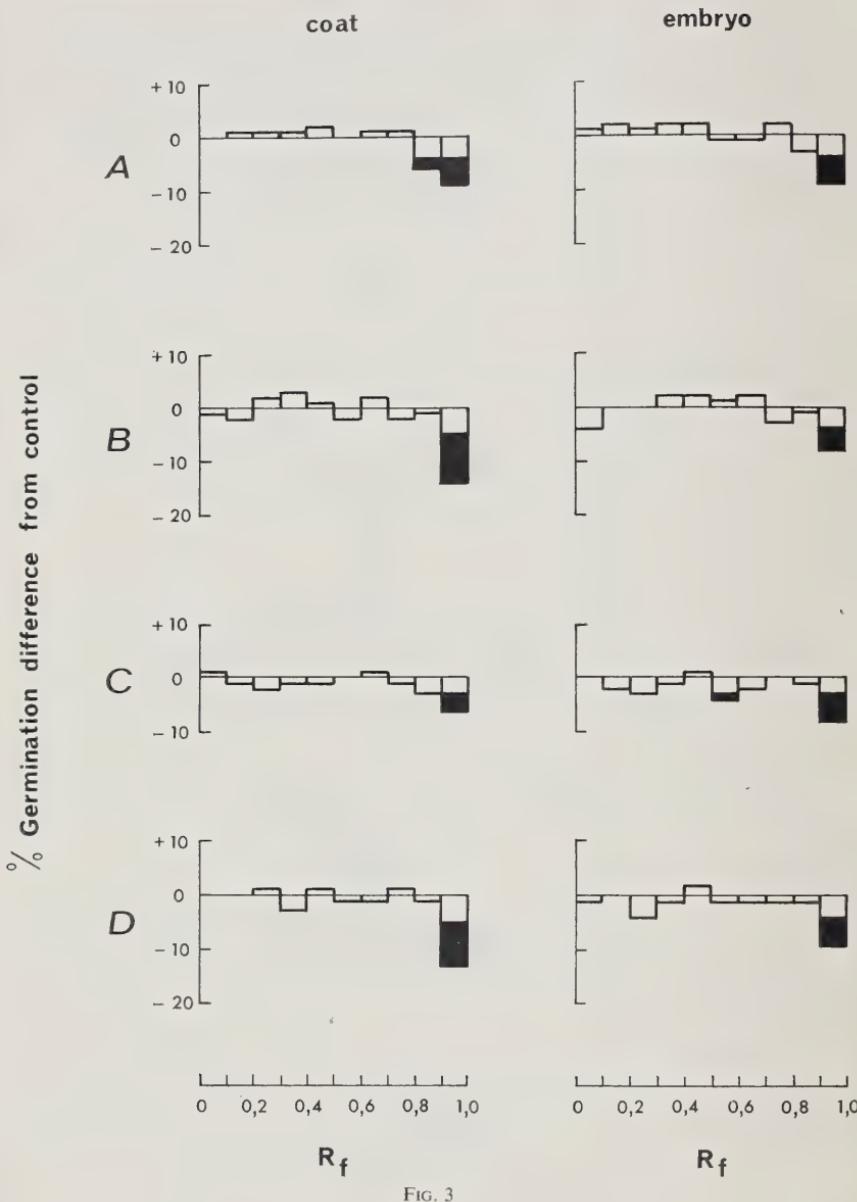
Fig. 3

(a) *Light germination of lettuce seed.* The bioassay used was based on the techniques of Sankhla and Sankhla (1968). Each strip from the chromatograms was placed in a petri dish, on one sheet of Whatman No. 1 filter paper and three ml distilled water was added. One hundred seeds of lettuce (var. Grand Rapids) were then scattered on the paper in each petri dish and the dishes were placed in the dark for two hours. The lettuce seeds were then exposed to cool white fluorescent light, with an intensity of 3.0×10 lumen/m², for 30 min. After illumination, the seeds were germinated in the dark in a growth cabinet maintained at 26°C. The percentage germination was recorded after 48 hours.

(b) *Dark germination of lettuce seed.* Essentially the same procedure as in (a) was followed. The only difference was that after the lettuce seeds were scattered on the filter paper in each petri dish, the dishes were immediately placed in the dark in a growth cabinet at 26°C. The percentage germination was recorded after 48 hours.

Chemicals.

(RS)-abscisic acid (ABA) was obtained through the courtesy of R. J. Reynolds Tobacco Company, North Carolina, U.S.A. The gibberellic acid (GA) used was the potassium salt of GA_3 purchased from Calbiochem, Los Angeles, California. Coumarin was obtained from L. Light and Company, Bucks, England.

RESULTS AND DISCUSSION

(i) *Chromatographic separation of water extracts and bioassay for the detection of germination inhibitors.*

Water extracts were separated in *n*-butanol:ammonia:water as, in this solvent system, abscisic acid separated out in the region of R_f 0,6 (Davison, 1965; Bowen and Hoad, 1968) and coumarin in the region of R_f 0,9 (Swain, 1953). (See Fig. 2.) Results of the bioassay after the separation of water extracts in *n*-butanol:ammonia:water are given in Figure 1. Some difficulty was experienced in obtaining an efficient separation of the embryo extracts of *Leucospermum cordifolium* and *Protea barbigera* in this solvent system. The significant band of inhibition at R_f 0,1 is regarded as being due to the poor separation of the extracts rather than indicating the presence of a specific inhibiting substance. The extracts of the other species all separated out well and, together with the embryo extract of *Protea barbigera*, gave bands of inhibition corresponding either to R_f 0,9 or 1,0 or spread over both values.

FIG. 3.
A comparison of the effects of water extracts of seed coats and embryos on the germination of "Grand Rapids" lettuce seed in light.
A = *Protea compacta;*   B = *P. barbigera;*   C = *Leucospermum cordifolium;*
D = *Leucadendron daphnoides.*
The solvent was ethyl acetate:ammonia. The shaded areas represent differences significant at 1% level.
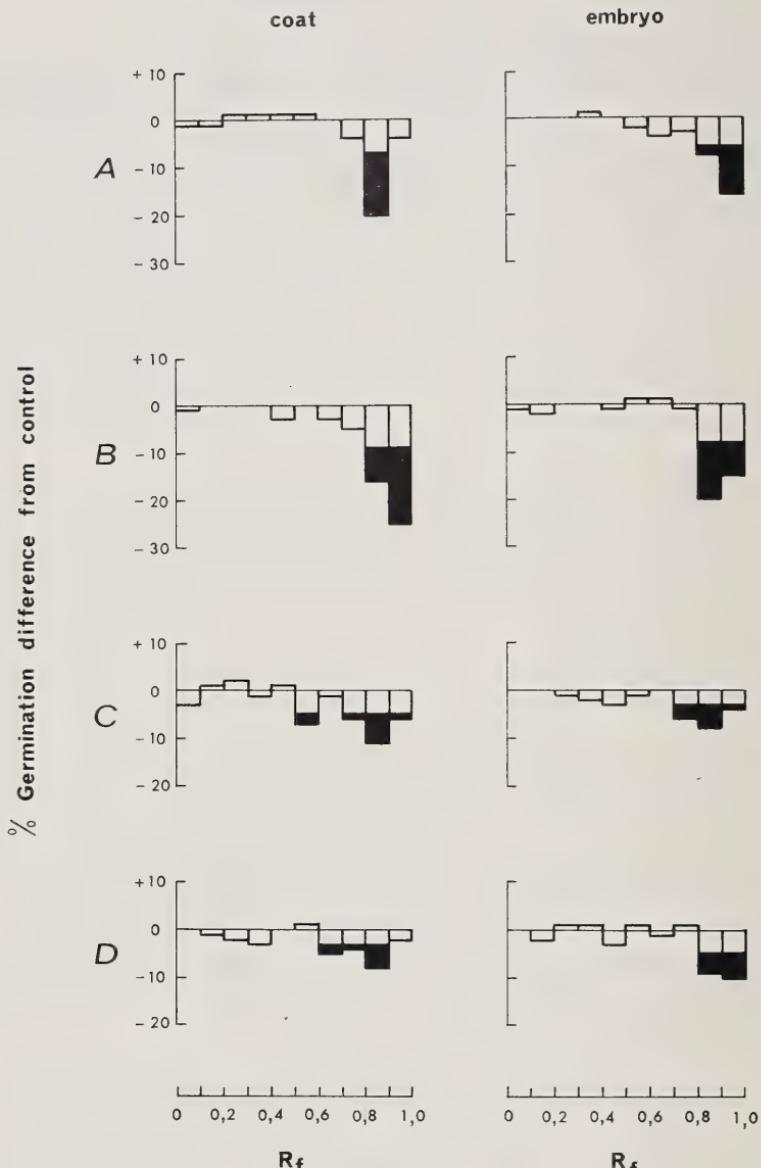
FIG. 4.

Seed coat extracts of *Protea compacta; P. barbigera,* and *Leucospermum cordifolium* showed a second band of inhibition corresponding to R_f 0,6 and the embryo extract of *Protea barbigera* a second band at R_f 0,5.

These results indicated that the major inhibitor of germination in the bioassay was a compound or compounds which separated out in a similar way to coumarin. They also indicated that the second inhibitor, which was present in some of the extracts, separated out to a position on the chromatogram broadly corresponding to the position of ABA.

In a third experiment water extracts were separated in ethyl acetate:2N ammonia. In this solvent system ABA separated out only very slowly and gave a band of inhibition at R_f 0,1. The coumarin standard alone and mixed with ABA gave inhibition corresponding to R_f 1,0 (See Fig. 2). Figure 3 shows that all the seed extracts gave a band of inhibition corresponding to R_f 1,0, with inhibition spreading over R_f 0,9 and 1,0 in the case of the seed coat extract of *Protea compacta.* The embryo extract of *Leucospermum cordifolium* also showed a zone of inhibition at R_f 0,7. These results tended further to suggest that the major inhibitor present in the seed extracts behaved in a manner similar to coumarin.

(ii) *Chromatographic separation of ether extracts and bioassay for the detection of germination promotors and inhibitors.*

A problem encountered in chromatographing the water extracts of seed was that the large number of water soluble substances present appeared to interfere with the efficient separation of the constituents of the extracts. In some cases this was partially overcome by loading smaller amounts of extract on any one strip of the chromatogram and increasing the number of strips. The separate strips were then all combined in the bioassays. A more satisfactory solution to the problem was to use different techniques for extracting the seeds. The extraction of seeds using ether was shown by Eagles and Wareing (1964) and Irving and Lanphear (1968) to be suitable for the extraction of growth inhibitors and promotors. Seeds of all species were extracted using ether and the extracts were separated in *n*-butanol:ammonia:water. Results of the bioassay for the detection of inhibitors are shown in Figure 4 and results for the standards are shown in Figure 2. After separation, all the seed extracts and the coumarin standard showed bands of inhibition corresponding to R_f 0,9—1,0. In addition, the seed coat extracts of *Leucospermum cordifolium* showed a band of inhibition at R_f 0,6 which corresponded with the ABA standard.

FIG. 4.
A comparison of the effects of ether extracts of seed coats and embryo on germination of "Grand Rapids" lettuce seed in light.

A = *Protea compacta;*   B = *P. barbigera;*   C = *Leucospermum cordifolium;*
D = *Leucadendron daphnoides*

The solvent was *n*-butanol:ammonia:water. Shaded areas represent differences significant at 1% level.
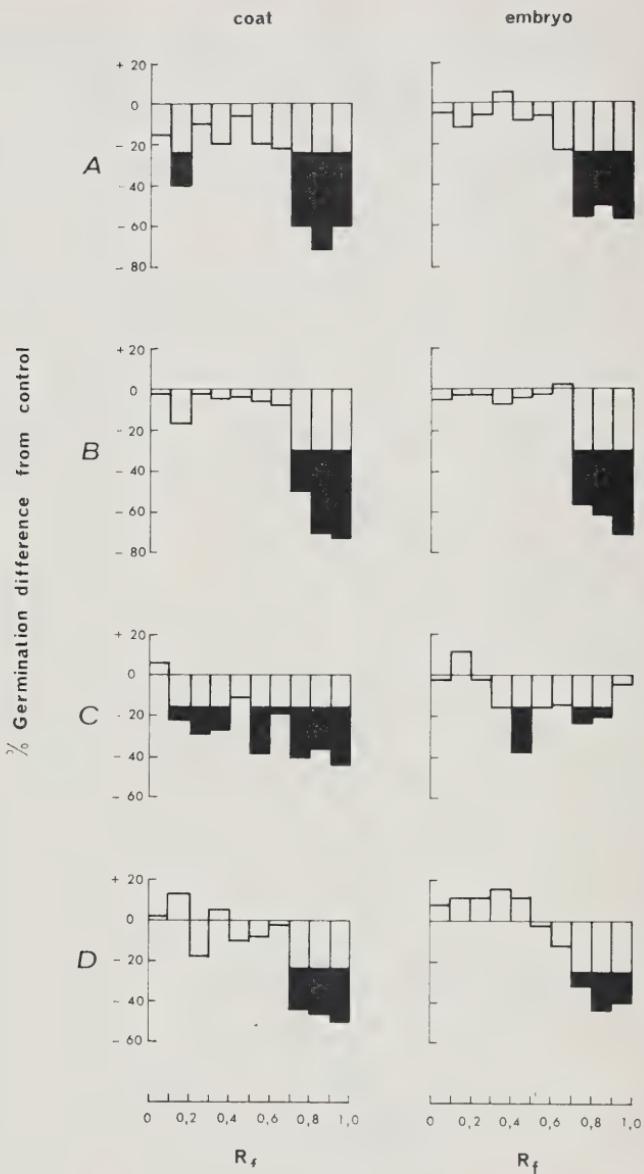
FIG. 5

Results of the bioassay (in the dark) for the detection of inhibitors and promotors in the ether extracts are shown in Fig. 5. The results for the ABA and coumarin standards were the same as those shown in Figure 2. The gibberellic acid standard (not shown) gave significant promotion of germination at R_f 0,3. All the seed extracts gave a band of inhibition in the region of R_f 0,8—1,0, which corresponded to that shown by the coumarin standard. In *Leucospermum cordifolium* the seed coat extract showed inhibition at R_f 0,6—0,7 and the embryo extract at R_f 0,5. The ABA standard gave inhibition at similar R_f values (0,5—0,6). Additional bands of inhibition were shown by *Leucospermum cordifolium* coat extracts at R_f 0,2—0,4 and *Protea compacta* coat extracts at R_f 0,2. No evidence of a promotor was obtained in any of the seed extracts. Bioassay results of the ether extracts suggested again that the major inhibitor present had properties similar to coumarin. One or more inhibitors with properties broadly similar to those of ABA were also present in some extracts.

(iii) *Chromatographic separation of ethyl acetate extracts and bioassay for the detection of germination inhibitors.*

As has been mentioned previously and can be seen in Fig. 1, a number of the water extracts gave inhibition in the bioassay in the region of R_f 0,5, a position which closely resembled that of ABA. In order to determine whether ABA was in fact present, an extraction technique used by Davis, Heinz and Addicott (1968) specifically for ABA, was used. Seeds were extracted using ethyl acetate and the extracts separated in *n*-butanol:ammonia:water. Results of the bioassay are given in Figure 6. Results for the standards are the same as in Fig. 2. With the exception of *Leucadendron daphnoides* embryo extract, the seed extracts of all species gave inhibition at R_f 0,9 or 1,0 as also shown by the coumarin standard.

It was interesting to note that although this extraction technique was not the most suitable for extracting coumarin (as the latter is not very soluble in acetone or in ethyl acetate) a substance with properties similar to coumarin was extracted in sufficient quantity to show inhibition in the bioassay.

The seed coat extracts of *Leucospermum cordifolium* and *Leucadendron daphnoides* were the only two extracts to show significant (1%) inhibition in the region of R_f 0,5—0,6 which broadly corresponds with the ABA control. These results indicate that ABA may either be present in extremely small concentrations, or absent.

FIG. 5.

A comparison of the effects of ether extracts of seed coats and embryos on germination of "Grand Rapids" lettuce seed in darkness.

A = *Protea compacta*;   B = *P. barbigera*;   C = *Leucospermum cordifolium*;
D = *Leucadendron daphnoides*

The solvent was *n*-butanol:ammonia:water. Shaded areas represent differences significant at 1% level.
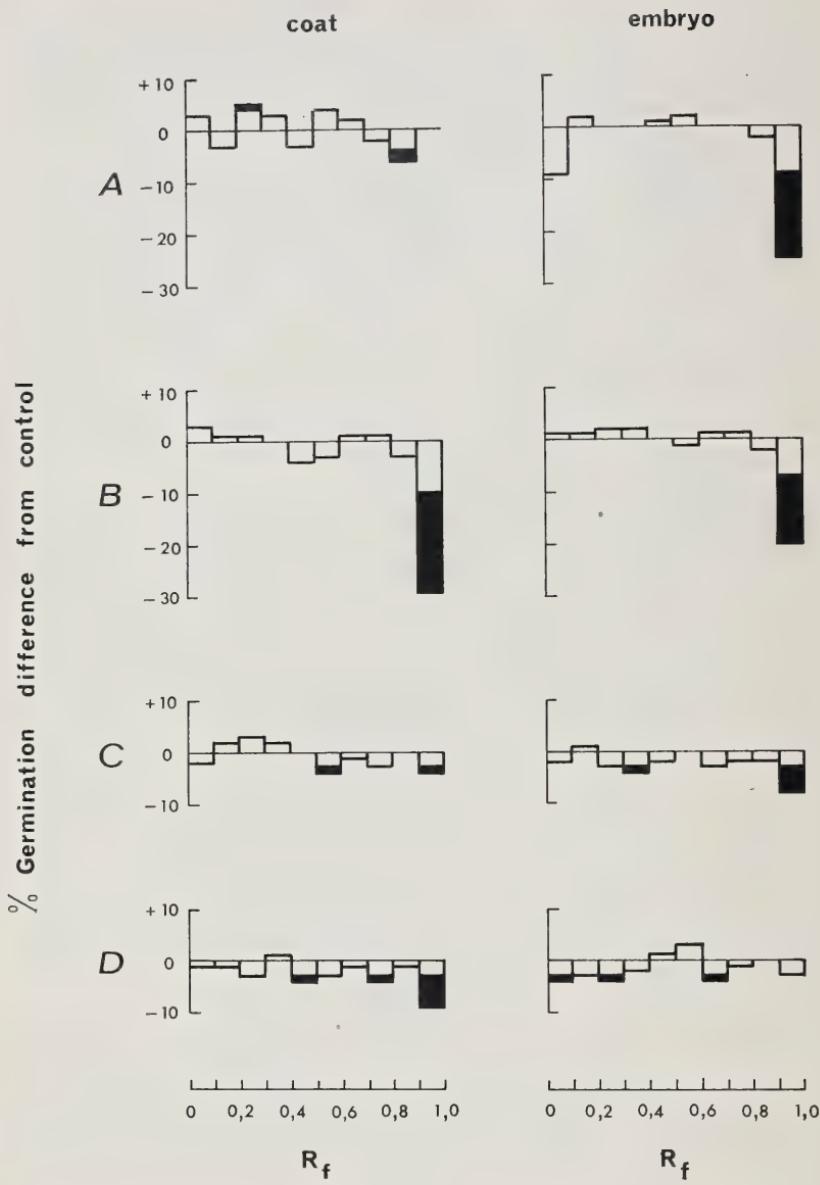
FIG. 6.

In an attempt to eliminate the concentration factor, six times the weight of seed normally used for extraction was extracted, using ethyl acetate. As seed supplies were limited, only *Protea compacta* was investigated. The extracts were separated in *n*-butanol: ammonia: water, the chromatogram cut into strips and each strip was eluted for 24 hours in 80% methanol. The pattern of absorption of each fraction of the seed coat and embryo extracts under UV was then analysed in a Zeiss DMR 21 Spectrophotometer.

These results (See Fig. 7) show the absorption spectra of coumarin and ABA standards, together with the chromatographed fractions of seed coat and embryo extracts. ABA shows peak absorption at 242 nm and coumarin at 272 nm. The inhibitor in the seed coat and embryo extracts which was shown up in the bioassay at R_f 1,0 (See Fig. 8), shows a peak similar to coumarin at 272 nm. The inhibitor present in the seed coat which separated out at R_f 0,5— 0,6 (Fig. 8), has peak absorption at 278 nm and can thus be seen not to be ABA.

In order to further characterize the inhibiting compound which had properties similar to coumarin, the seed extracts of all species were chromatographed in three different solvent systems and the chromatograms were then treated with a number of spray reagents. Each reagent gave a characteristic colour reaction in the presence of coumarin (Swain 1953). The average R_f value for the inhibiting compound in *iso*-propanol: ammonia: water was 0,91 (coumarin control R_f 0,92). In *n*-butanol: ammonia: water the R_f was 0,92 (coumarin control R_f = 0,92) and in ethyl acetate ammonia R_f was 0,93 (coumarin control R_f = 0,94). The compound which appeared at these R_f values showed up with a yellow/green fluorescence when irradiated with UV after spraying with 2N NaOH. No fluorescence was obtained without pretreatment with NaOH. The active spot also reacted with aqueous 1% potassium permanganate giving a yellow colour. These reactions indicate that the compound is coumarin-like, being in accord with the behaviour described for coumarin by Swain (1953).

The overwhelming evidence is thus that the major inhibitor in the species studied is coumarin-like in its properties. A number of other inhibitors have also been shown to be present. However, no evidence for the presence of ABA in detectable quantities in the seed of *Protea compacta* was found. This does not necessarily preclude ABA from being present in the seed of other species.

FIG. 6.

A comparison of the effects of ethyl acetate extracts of seed coats and embryos on the germination of "Grand Rapids" lettuce seed in light.

A = *Protea compacta;*   B = *P. barbigera;*   C = *Leucospermum cordifolium;*
                        D = *Leucadendron daphnoides*

The solvent was *n*-butanol:ammonia:water. Shaded areas represent differences significant at 1% level.

WAVELENGTH [mμ]
FIG 7.
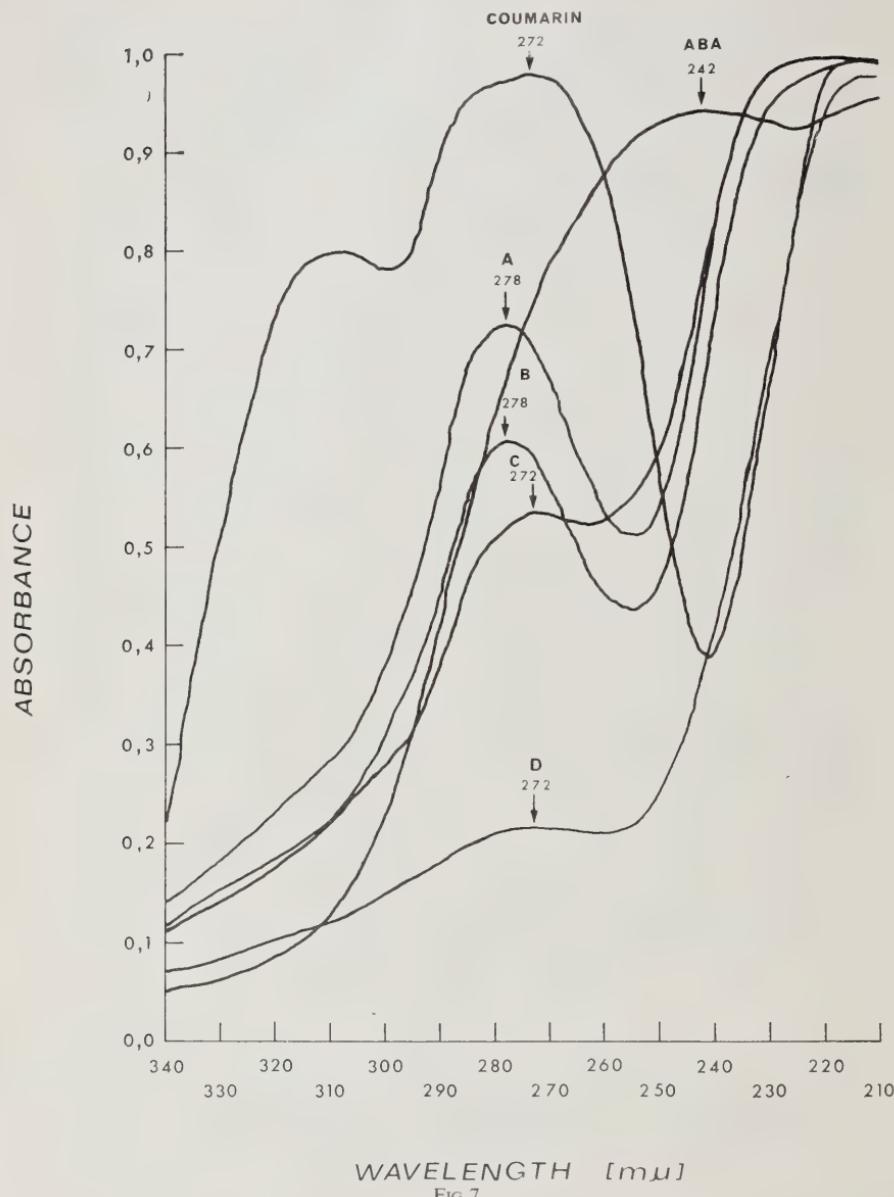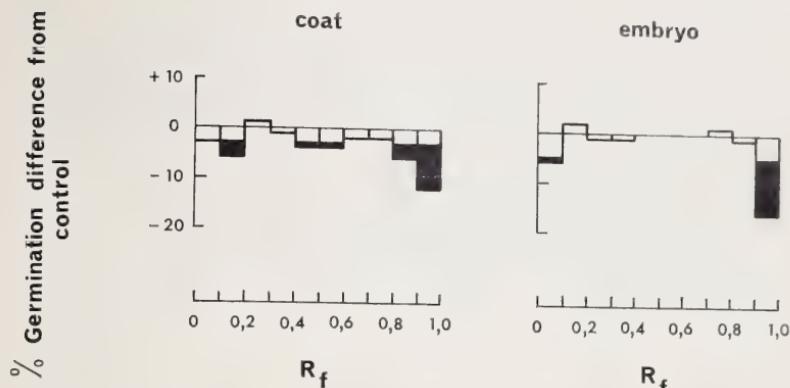
FIG. 8.

A comparison of the effect of ethyl acetate extracts of seed coat embryo of *Protea compacta* on germination of "Grand Rapids" lettuce seed in light. The values of the coat and embryo extracts are for the assay of 90 gms seed (6 × weight used in earlier assays). The solvent was *n*-butanol:ammonia:water. Shaded areas represent differences significant at 1% level.

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FIG. 7.

A comparison of the UV absorption spectra of ABA and coumarin and the ethyl acetate extracts of the seed coat and embryo of *Protea compacta*. The solvent was *n*-butanol:ammonia: water.

A = coat (R_f 0,5)   B = coat (R_f 0,6)   C = coat (R_f 1,0)   D = embryo (R_f 1,0)

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STUDIES IN THE BULBOUS LILIACEAE IN SOUTH AFRICA: 2. *DRIMIOPSIS* AND *RESNOVA*.

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ABSTRACT

The affinities of *Drimiopsis* and *Resnova* are discussed. Reasons for placing *Resnova* in synonymy under *Drimiopsis* are given and the five species of *Drimiopsis* recognised are dealt with taxonomically. A key to the species is constructed and certain modifications to the generic key to the bulbous Liliaceae in Phillips' "The Genera of South African Flowering Plants" proposed. An investigation of the meiotic chromosomes of two specimens of *D. maculata* is reported.

UITTREKSEL

STUDIES VAN DIE BOLDRAENDE LILIACEAE IN SUID AFRIKA: 2. *DRIMIOPSIS* EN *RESNOVA*.

Die verwantskappe tussen *Drimiopsis* en *Resnova* word bespreek. Redes vir die plasing van *Resnova* as 'n sinoniem onder *Drimiopsis* word aangegee en die vyf erkende soorte *Drimiopsis* word taksonomies behandel. 'n Sleutel tot die soorte word saamgestel en sekere veranderinge word voorgestel vir die generiese sleutel tot die boldraende Liliaceae in Phillips ,,The Genera of South African Flowering Plants". 'n Ondersoek na die meiotiese chromosome van twee monsters van *D. maculata* word oor verslag gedoen.

INTRODUCTION

The genus *Drimiopsis* was described in 1851/2 by Lindley, with a single species—*D. maculata*. J. G. Baker described a further seven species from South Africa between 1870 and 1897. In addition he described *Scilla humifusa* and *S. lachenalioides*, which are considered by the present author to belong to this genus. A further three species have been described from South Africa this century and four species from South West Africa. The South West African species are considered by the present author to belong to the genus *Ledebouria*.

In 1946 Van der Merwe described a new genus, *Resnova*, from South Africa. Two species, described by Baker under *Scilla*, and four new species were recognised. No further species have been described in *Resnova* and Phillips (1951) treated *Resnova* as a synonym for *Scilla*.

As pointed out by Van der Merwe (1946), Baker did apparently place very closely related species under different subgenera of *Scilla*—*S. lachenalioides* under *Euscilla* and *S. humifusa* under *Ledebouria*. What has not been discussed is the relationship between *Scilla* (sensu lato) and *Drimiopsis*. The relationships between these two groups is discussed in this paper. A re-evaluation of the

subgenera of *Scilla*, as represented in South Africa, has been discussed by Jessop (1970), and with the reorganisation of the *Drimiopsis-Resnova* group, it has been decided also to publish a key indicating features for separating the genera recognised in these papers and certain other allied genera. A taxonomic treatment of the species in the *Drimiopsis-Resnova* group is also provided.

GENERIC CONCEPTS

Baker (1896/7) described *Drimiopsis* as having "Perianth-segments cucullate, connivent", and *Scilla* as having "Perianth-segments spreading, 1-nerved". Phillips (1951) also employed the cucullate apices to the perianth segments in his key.

In describing *Resnova*, Van der Merwe (1946) distinguished his new genus from the subgenus *Euscilla* by its having ascending perianth segments, which are never blue or blue-purple. From the subgenus *Ledebouria* he separated it by its not having spreading perianth segments, in the sessile ovary and in the colour (undefined) of the perianth.

From these published comments, it would seem that the perianth affords the principal diagnostic characters of the groups—spreading in *Scilla* (both sub-genera), ascending in *Resnova* and cucullate and connivent in *Drimiopsis.*

On morphological characters, *Drimiopsis*, *Resnova* and *Ledebouria* appear to be very closely related. The bulbs of *Resnova* and *Drimiopsis* are made up entirely of rather loose fleshy scales, while those of *Ledebouria* tend to be more closely packed and the outermost are usually dry and papery. However, in *L. cooperi* bulbs very similar to those of the other two genera are frequent. The leaves of all three are similar in texture, and are frequently spotted or in other ways marked. Petioles occur more frequently in *Drimiopsis* and *Resnova* than in *Ledebouria*. The inflorescence is similar. The ovary of *Ledebouria* is of a very characteristic form—being generally markedly conical and stipitate, with two basal ovules in each locule. The ovaries of both *Drimiopsis* and *Resnova* are oblong and sessile but also have two basal ovules per locule. The perianth characters are not considered to be as significant as previous authors have suggested. Many specimens of *Ledebouria* have minutely cucullate perianth segments. The colour of the perianth segments is extremely variable in *Ledebouria*, *Drimiopsis* and *Resnova*.

The differences between *Drimiopsis* and *Resnova*, and *Scilla* (sensu Jessop, 1970) are more clearly defined. *Scilla* always has some dry bulb scales, has firmer, unspotted leaves, and a more rigid peduncle. The filaments are always distinctly fused towards the base, and there is frequently more than two ovules in each locule of the ovary.

It is, therefore, considered that further information is desirable in discussing affinities between *Drimiosis*, *Resnova* and *Ledebouria*. Fresh material of *Resnova*

has not been available for this study, but a certain, limited, amount of work has been possible on *Drimiopsis*.

As in distinguishing *Scilla* from *Ledebouria* (Jessop, 1970), it has been considered desirable to investigate the bulb apex.

Only one species of *Drimiopsis* has been available for this investigation. In *D. maculata*, a longitudinal section shows the deviation of the vascular tissue to the inflorescence from the apparently main axis terminating in the vegetative apical bud. Figure 1 illustrates the vascular pattern occurring in *Scilla*, *Ledebouria* and *Drimiopsis*, confirming the closer affinity of *Drimiopsis* with *Ledebouria* than with *Scilla*.
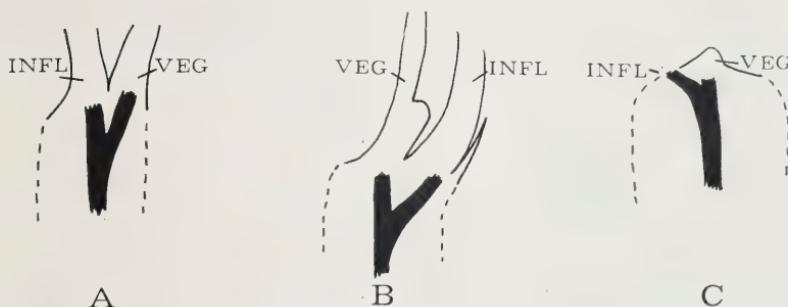
Fig. 1.
Diagrams of longitudinal sections through the bulb apices of *Scilla*, *Ledebouria* and *Drimiopsis*.
A. *Scilla nervosa*.   B. *Ledebouria revoluta*.   C. *Drimiopsis maculata*.
INFL—inflorescence axis.   VEG—vegetative axis.
Broken lines indicate region of bulb where scales and portions of the bulb axis have been cut away. (Not drawn to scale.)

Leaf anatomy of *D. maculata* is very similar to that of *Ledebouria*. There is no lignified sheath around the vascular bundles. It does differ in not having a palisade layer, but this is not considered significant as this layer is extremely poorly developed in *Ledebouria* (fig. 2).

CYTOLOGY

Four papers, dealing with *Drimiopsis* chromosomes, have been published. Sato (1942) recorded $2n = 64$ for *D. maculata*, while Fernandes and Neves (1962) reported $2n = 60$ for the same species. Diploid numbers of 20 have been recorded for *D. burkei* (sub *D. crenata*) and *D. maxima* (sub *D. saundersiae*) by De Wet (1957). Matsuura and Suto (1935) found $2n = 80$ in *D. botryoides*, which is a species from tropical Africa.

Only two specimens of *D. maculata* have been examined by the present author. In both, laggards and micronuclei were observed (fig. 3). For *Strey 9031*
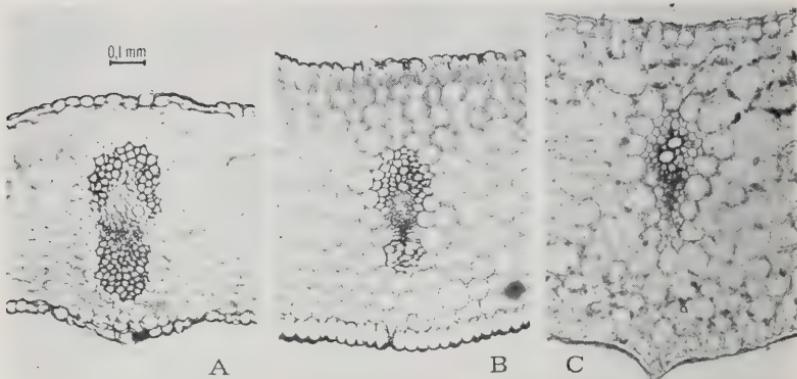
FIG. 2.
Transverse sections of leaves of *Scilla*, *Ledebouria* and *Drimiopsis*.
A. *Scilla natalensis*.   B. *Ledebouria undulata*.   C. *Drimiopsis maculata*.

(Manteka, Lusikisiki) a haploid number of 15 was obtained. The average length for the longest chromosome in each of five cells was 7,8 μm and the average for the shortest in each of these cells was 2,5 μm. The standard deviations are 0,91 and 0,38 respectively. For *Jacot Guillarmod s.n.* (Port St Johns) it was not possible to determine a number, probably because irregularities in meiotic divisions produced varying numbers, but a haploid number of approximately 26 was estimated.

There appears, as in *Ledebouria*, to be little significance in chromosome numbers. No basic number for the genus is suggested and it does not seem likely that chromosome numbers would be any more relevant to the separation of taxa than in *Ledebouria*. The occurrence of abnormalities in meiotic divisions, as have been found in *Ledebouria* (Jessop, ined.), may indicate reproductive abnormalities and may be related to the difficulties in defining subgeneric taxa in this genus. The range in size of the chromosomes and the size of the largest are greater than in *Ledebouria* (Jessop, ined.), as *Ledebouria* meiotic chromosomes rarely exceed 5–6 μm.

CONCLUSIONS

On the basis of the above information, it is clear that *Drimiopsis* (sensu stricto) is very close to *Ledebouria*. Although many aspects of *Resnova* have not been investigated, it is considered that there is no character on which it can be separated from *Drimiopsis*. It is, therefore, proposed that *Drimiopsis* and *Resnova* be combined under the older name—*Drimiopsis*—and that this genus be placed near *Ledebouria*.
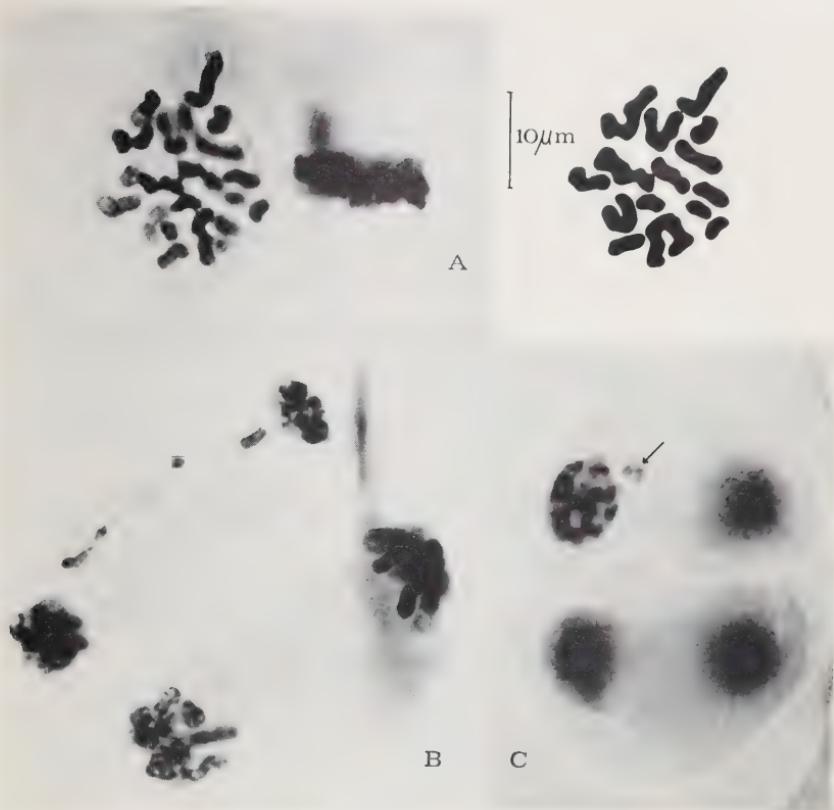
FIG. 3.
Meiotic chromosomes of *Drimiopsis maculata* (*Strey 9031*).
A. Metaphase II.   B. Anaphase II showing laggards.
C. Telophase II showing micronucleus—arrowed.

KEY TO THE GENERA

Because of the changes made in the generic definitions in both this paper and the previous one (Jessop, 1970), it is considered desirable to publish a revision of the relevant sections of Phillip's (1951) key.

Phillips includes most of the bulbous Liliaceae under his lead 27. Most of the key following on from this key has been left unaltered, but a few errors are corrected. The numbers used for the leads in this key replace those similarly numbered by Phillips.

28.   Filaments connate at the base   29
      Filaments free   36

29.   Flowers arcuate; bulb scales with fibrous apices   .   .   **47. Pseudogaltonia** Kuntze
      Flowers straight; bulb scales rarely with fibrous apices   30

30.   Perianth segments free or, if fused, not forming a distinct tube   31
      Perianth segments fused to form a distinct tube   32

31.   Perianth ascending; placentation of ovules basal   .   .   .   .   **45. Drimiopsis** Lindl.
      Perianth spreading; placentation of ovules axile   .   .   .   .   .   .   **42. Scilla** L

32.   Inflorescence a corymb; stamens in two rows; leaves surrounded by a membranous
             tubular sheath protruding from within the fleshy scales of the bulb   .   .   .   33
      Inflorescence a lax raceme, sometimes spicate or head-like; stamens in one row;
             leaves surrounded by the fleshy scales of the bulb only   34

33.   Inflorescence with not more than four flowers; leaves less than 4 mm broad
                                                                            46. Hyacinthus L.
      Inflorescence with more than four flowers; leaves usually more than 4 mm broad
                                                                            50. Polyxena Kunth.

34.   Perianth-segments longer than the tube; inflorescence a dense subspicate raceme
                                                                            52. Whiteheadia Harv.
      Perianth-segments shorter than the tube; inflorescence a lax raceme or a shortly
             peduncled raceme or sometimes the raceme head-like   35

35.   Leaves linear   .   .   .   .   **53. Neopatersonia** Schonl.
      Leaves elliptic or ovate   .   .   .   .   **51. Neobakeria** Schltr.

36.   Perianth-tube O; stamens hypogynous or inserted at the base of the perianth-seg-
             ments   37
      Perianth-tube present; stamens inserted on the perianth-tube.   42

37.   Aerial parts consisting only of the much-branched inflorescence, which is green
                                                                            19. Schizobasis Bak.
      Aerial parts consisting of leaves and simple, racemose inflorescences—which are
             not always present at the same time   38

38.   Lowermost bracts spurred; seeds more or less flattened, with rather loose testa .   .   39
      Lowermost bracts not spurred; seeds variable in shape, but not flattened and with
             a testa which fits firmly around the endosperm   40

39.   Lower portion of filaments flattened; perianth-segments reflexed   .   .   .   .   .
                                                                            34. Thuranthos C.H.Wr.
      Filaments not flattened or flattened above the lower portion; perianth segments
             more or less spreading   .   .   .   .   **35. Urginea** Steinh.

40.   Bulb scales tubular at least at the base; leaves more or less uniformally green;
             ovary with more than two ovules per chamber   .   .   .   .   **44. Ornithogalum** L.
      Bulb scales imbricate; leaves frequently spotted or striped; ovary with two ovules
             per chamber   41

41.   Perianth-segments more or less ascending; ovary oblong, sessile; leaves often
             petiolate; bulb scales all fleshy   .   .   .   .   **45. Drimiopsis** Lindl.
      Perianth-segments usually spreading or reflexed from near the middle; ovary
             conical, stipitate; leaves rarely petiolate; outer bulb scales usually mem-
             branous   .   .   .   .   **45a. Ledebouria** Roth

42.   Inflorescence of one or two flowers   .   .   .   .   **41. Litanthus** Harv.
      Inflorescence a raceme, more rarely a spike   43

43.   Perianth-segments distinctly dissimilar   44
      Perianth-segments similar, more rarely slightly dissimilar   45

44.   Perianth deciduous; the outer segments usually longer than the inner   **40. Dipcadi** Medik.
      Perianth persistent; the inner segments usually longer than the outer   .   .   .   .
                                                                            49. Lachenalia Jacq.

45.   Ovary with two ovules in each chamber   .   .   .   .   .   **48. Veltheimia** Gleditsch
      Ovary with few to many ovules in each chamber   46

46.   Anthers connivent .   .   .   .   **39. Rhadamanthus** Salisb.
      Anthers not connivent 46a

46a. An inconspicuous plant with narrow terete leaves . . . . **35. Urginea** Steinh.
    More or less robust plants; leaves not narrow and terete 46b
46b. Stamens inserted below the perianth-throat . . . . **37. Galtonia** Decne.
    Stamens inserted in the perianth-throat . . . . **38. Drimia** Jacq.

DRIMIOPSIS LINDL.

Paxton's Flower Garden **2:** 73 (1851–2)

Resnova V.d. Merwe in Tydskr. Wetensk. Kuns N.R. **6:** 41–46 (1946). Type species: not indicated.

Bulbs present, lacking papery outer scales. *Leaves* all basal, sometimes petiolate, generally with spots or patches of a different shade of green from the rest of the lamina. *Inflorescence* suberect, originating from an axillary bud, always unbranched. *Bracts* vestigial, not spurred. *Perianth segments* similar or almost so, ascending, sometimes with the apices incurved and cucullate, white, green, pink or purple, sometimes with a purplish or brown longitudinal marking. *Filaments* free of one another or very shortly connate, epipetalous. *Ovary* oblong, sessile, with two ovules per locule. *Ovules* basal.

Type: D. maculata Lindl.
Distribution: Eastern Cape through Natal and the Transvaal into tropical Africa.

KEY TO SPECIES OF DRIMIOPSIS IN SOUTH AFRICA

Apices of perianth segments erect-spreading. Flowers usually more than 5 mm long.
    Flowers pink to purple, not conspicuously striped, 10 mm or more long. Transkei to
        Underberg and Pietermaritzburg . . . . 1. *lachenalioides*

    Flowers striped, often partly pink, 9 mm or less long. To the east and north of Durban,
        with a few records from the eastern Cape as far west as Bedford and East London
                                                                    2. *maxima*

Apices of perianth segments incurved to cucullate. Flowers usually less than 5 mm long.
    Flowers usually more than 4 mm long, apparently always green, often white in the bud.
        Leaves cordate at the base . . . . 4. *maculata*

    Flowers usually less than 3 mm long, often with pink or brown markings. Leaves usually
        cuneate, less often cordate, at the base.

        Flowers greenish, white, or if purplish then the leaves with cuneate bases   3. *burkei*
        Flowers purple. Leaves usually cordate at the base . . . . . 5. *atropurpurea*

1. **Drimiopsis lachenalioides** (Bak.) Jess., comb. nov.

Scilla lachenalioides Bak. in Fl. Cap. **6:** 482 (1897). *Type:* "Transkei", *Hallack;* "Bazeia Mountain", *Baur* 549 (SAM! PRE, photo.!); "Griqualand East", Maloine, near Clydesdale Tyson 2878 (BOL!; SAM!, PRE, photo.!).
Resnova lachenalioides (Bak.) V.d.Merwe in Tydskr. Wetensk. Kuns **6:** 46 (1946).

Bulb 30—40 [—80] mm long. *Leaves* 2—4, subpetiolate, glabrous to pubescent, [70—] 100—200 [—250] mm long, [12—] 25—40 mm broad. *Inflorescence* generally a little longer than the leaves. *Pedicels* 1—3 mm long. *Flowers* pink to purple. *Perianth segments* ascending with erect-spreading, minutely cucullate. apices, [9—] 10—12 [—18] mm long.

Recorded between Umtata and Pietermaritzburg. A single record from Zululand (2728 (Frankfort): Hlobane, *Johnstone* 574 (NH)) may be better placed under *D. maxima.* Occurs in grassveld and possibly forest.

Specimens linking this species with *D. maxima* do occur (e.g. 2832 (Mtuba-tuba): Hluhluwe Game Reserve, *Ward* 3281; PRE & NH, which has been placed in *D. maxima*). Size and markings of perianth is used, somewhat artificially, to separate these species. Distribution also provides a useful feature. For illustration see Flower. Pl. S. Afr. **21**: t.824 (1941).

Selected specimens:

NATAL–2929 (Underberg): Giants Castle Game Reserve, *Trauseld 877* (PRE); flats near Bulwer, *Lansdell* s.n. sub NH *34265* (NH). 2930 (Pietermaritzburg): Pietermaritzburg district, *Mitchell 13* (PRE). 3030 (Port Shepstone): near Sezela, *Reynolds* s.n. (PRE).
CAPE–?3029 (Kokstad): "Ingeni", Mount Ayliff, *Brownlee* s.n. (PRE). 3128 (Umtata): Bazija Forest Station, *Killick & Marais 2063* (PRE).

2. **Drimiopsis maxima** Bak. in Fl. Cap. **6**: 474 (1897).

Type: Natal, near Botha's, *Wood* 4773 (K, holo.!; NH!, PRE, photo.!).
Drimiopsis saundersiae Bak. in Fl. Cap. **6**: 474 (1897). *Type:* "Natal, Itafamasi", *Wood* 774 (K, lecto.!), 938 (K, iso.!); without precise locality, *Saunders* s.n. (K!).
Scilla humifusa Bak. in Gard. Chron. **15**: 626 (1881). *Type:* ex cult. hort. Bull (K, holo.!).
Drimiopsis humifusa (Bak.) Bak. in Fl. Cap. **6**: 474 (1897).
Scilla schlechteri Bak. in Bull. Herb. Boiss. **2**: 1002 (1904). *Type:* Natal, Krantzkloof, *Schlechter* 3174 (K, holo, BOL, drawing!; BOL!, PRE, photo.!; GRA!, PRE, photo.!; PRE!; Z!).
Resnova schlechteri (Bak.) V. d. Merwe in Tydskr. Wetensk. Kuns. **6**: 46 (1946).
Resnova transvaalensis V.d.Merwe in Tydskr. Wetensk. Kuns **6**: 46 (1946). *Type:* Transvaal, Piet Retief district, Amsterdam, *Van der Merwe* s.n. sub PRE 26432 (PRE, holo.!).
Resnova pilosa V.d.Merwe in Tydskr. Wetensk. Kuns **6**: 46 (1946). *Type:* Natal, Vryheid, *Van der Merwe* 2643 (PRE, holo.!).
Resnova minor V.d.Merwe in Tydskr. Wetensk. Kuns **6**: 46 (1946). *Type:* Natal, Paulpieters-burg, *Van der Merwe* 2780 (PRE, holo.!).
Resnova maxima V.d.Merwe in Tydskr. Wetensk. Kuns **6**: 46 (1946). *Type:* "In collibus prope Magut", *Van der Merwe* 2710 (PRE!). The specimen of the type number annotated as the type in the National Herbarium, Pretoria, are labelled "Dwarsberg (Louwsberg)".

Bulb 30—50 [—100] mm long. *Leaves* 2—4 [—8], subpetiolate or narrowing gradually to the base, the margins sometimes undulate, glabrous to pubescent, [60—] 80—150 [—300] mm long, [13—] 30—50 [—70] mm broad. *Inflorescence* about the same length as the leaves to several times as long. *Pedicels* 1—2 [—3] mm long. *Flowers* striped, pink, white, green or brown. *Perianth segments* ascending, with erect-spreading, minutely cucullate apices, [5—] 6—8 [—9] mm long.

Widespread in Natal as far west as Hillcrest, Swaziland, and the south-eastern Transvaal. Isolated specimens have also been collected in the eastern Cape. Grows in grassveld, among rocks, in shallow pans and in forest.

Specimens intermediate between this species and *D. burkei* have been collected. It is separated by the present author from *D. burkei* on rather artificial criteria. It is also not always readily separable from *D. lachenalioides.* For illustration see Flower. Pl. S. Afr. **21**: t.823 (1941).

3. **Drimiopsis burkei** Bak. in Saund. Ref. Bot. **3**, app. 17 (1870).

Type: Transvaal, Aapies River, *Burke* s.n. (K, holo.!).
Drimiopsis woodii Bak. in Fl. Cap. **6**: 473 (1897). *Type:* Natal, Inanda, *Wood* 656 (NH!, PRE, photo.!; BOL!; SAM!); Natal, Klip River, *Sutherland* s.n. (K!).
Drimiopsis crenata V.d.Merwe in Flower. Pl. Afr. **25**: t.975 (1946). *Type:* Transvaal, Rooiberg, *Van der Merwe* 2805 (PRE, holo.!).

Bulb [20—] 30—60 [—90] mm long. Leaves usually 2—4, narrowing towards the base or sometimes subpetiolate, often with finely crenate or undulate margins, glabrous or rarely sparsely pubescent, [20—] 40—100 [—150] mm long, [10—] 20—40 [—50] mm broad. *Inflorescence* about the same length as the leaves to several times as long. *Pedicels* 1—2 mm long. *Flowers* green, white or pale pink. *Perianth segments* ascending with incurved, cucullate apices, usually 2—3 mm long.

Widespread in a wide range of habitats in the Transvaal and present in Botswana and Natal.

Some plants, especially those from damper areas and the Transvaal lowveld (for example the types of *D. woodii*), have longer leaves than those from the highveld of the Transvaal. These plants are often close to *D. maculata* in leaf form, but the leaves tend to be more cuneate. Their inclusion under *D. burkei* is principally on the basis of their smaller flowers. For illustration of the typical form see Flower. Pl. Afr. **25**: t.975 (1946), and for the longer leafed form see Flower. Pl. Afr. **25**: t.988 (1946).

4. **Drimiopsis maculata** Lindl. in Paxt. Flow. Gard **2**: 73, f.172 (1851-2).

Type: "Cape of Good Hope, introduced by the Horticultural Society", without collector, in Herb. J. Lindley (CGE, ?holo., K, photo.!).
Drimiopsis minor Bak. in Saund. Ref. Bot. **3**: t.192 (1870). *Type:* Saund. Ref. Bot. **3**: t.192 "Natal, *Cooper*" (1870).

Bulb [15—] 25—40 [—50] mm long. *Leaves* usually 2—4, usually cordate above the distinctly petiole-like base, erect to spreading, glabrous, [50—] 100—200

[—300] mm long, [20—] 35—70 [—80] mm broad. *Inflorescence* usually much longer than the leaves. *Pedicels* 1—2 mm long. *Flowers* white or green. *Perianth segments* ascending with incurved, cucullate apices, usually 4—5 mm long.

Occurs mainly in shaded places in dampish areas of the eastern Cape, Natal, Swaziland and occasionally recorded from the Transvaal, especially in the east.

The specimen cited as the type of *D. maculata* is a very good match of the figure in Paxton's "Flower Garden", but there is no indication on the herbarium sheet that this was made from the same material.

The type of *D. woodii* and other material similar to it have been collected over a wide part of the range of *D. maculata* as recognised by the present author. These specimens have narrower leaves, lacking the cordate base, and flowers only about 3 mm long. They are, therefore, to some extent intermediate between this and the previous species, but have been placed in *D. burkei* on the basis of their smaller flowers and cuneate leaves. For illustration of *D. maculata* see Flower. Pl. S. Afr. **24:** t.957 (1944).

Selected specimens:

TRANSVAAL–2430 (Pilgrim's Rest): 4 miles north of Branddraai, Lydenburg district, *Codd & De Winter 3261* (PRE).
SWAZILAND–2631 (Mbabane): Red Tiger Ranch, Manzini, *Compton 32432* (NBG, PRE).
NATAL–2632 (Bella Vista): Ndumo Game Reserve, *Tinley & Ward 35* (NH, PRE). 2931 (Stanger): Berea, *Wood* s.n. (GRA, NH); Durban, *Rabinowitz* s.n. sub BOL *24586* (GRA); Glen Mill, Lower Tugela, *Moll 2289* (PRE).
CAPE–3129 (Port St Johns): Third Beach, Port St Johns, *Strey 4322* (PRE). 3327 (Peddie): East London, *Rattray 576* (GRA), *7881* (PRE).

5. **Drimiopsis atropurpurea** N.E.Br. in Kew Bull. 1921: 299 (1921).

Type: Transvaal, Barberton, Roses Creek, *Thorncroft 1083* (BOL!, GRA!, PRE!).
Drimiopsis purpurea V.d.Merwe in Flower. Pl. Afr. **25:** t.975 (1946). *Type:* Natal, Paulpietersburg district near Pivaan, *Van der Merwe 2781* (PRE, holo.!).

In most features this species is similar to *D. maculata*. However, it differs in the following respects: *Leaves* pubescent. *Flowers* purple, approximately 2—4 mm long.

Little is known about its distribution or habitat. It has been recorded from northern Natal and the south-eastern Transvaal.

Selected specimens:

TRANSVAAL–2530 (Lydenburg): Waterval Boven, *Rogers 18508* (PRE); Belfast district, Schoemans Kloof, *Young A297* (PRE).
NATAL–2730 (Vryheid): Paulpietersburg district near Luneberg, *Van der Merwe 2779* (PRE).

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INDEX TO PRINCIPAL REFERENCES IN "STUDIES IN THE BULBOUS LILIACEAE" PARTS 1* AND 2.

Italicised page references are used for part 2.

NOTES ON *EMPODIUM* AND A NEW SPECIES OF *PAURIDIA*

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ABSTRACT

The combination, *Empodium veratrifolium* (Willd.) Thompson, is made. A new species, *Pauridia longituba* Thompson, is described.

UITTREKSEL

AANTEKENINGE OOR *EMPODIUM* EN 'N NUWE SOORT *PAURIDIA*.
Die kombinasie, *Empodium veratrifolium* (Willd.) Thompson, is gemaak. 'n Nuwe spesie, *Pauridia longituba* Thompson, is beskryf.

EMPODIUM SALISB.

In Kew Bulletin (1962) Bullock discussed the correct name for the taxon known variously as *Fabricia* Thunb., *Forbesia* Eckl. ex Nel, *Empodium* Salisb. and *Curculigo* Gaertn. section *Empodium* Benth. He showed *Empodium* Salisb. to be the legitimate name with *Empodium plicatum* (L.f.) Salisb. as the type of the genus. He reduced *Forbesia* to synonymy but did not make the necessary species combinations. As the genus is still being studied and some of the names may need to be reduced to synonymy, I do not wish to make the combinations now except for the species included in a book to be published later this year.

Empodium veratrifolium (Willd.) Thompson comb. nov.
Hypoxis veratrifolium Willd., Sp. Pl. **2**: 109 (1799).
Curculigo veratrifolia Bak., in J. Linn. Soc. **17**: 123 (1878).
Hypoxis plicata Jacq. Ic. 2, t. 367 (1795) Excluding synonyms.
Curculigo plicata Ait. var. *veratrifolia* Bak. in Fl. Cap. **6**: 173 (1896).
Forbesia plicata (Ait.) Nel var. *veratrifolia* (Bak.) Nel in Bot. Jahrb. **51**: 290 (1914).
Although Baker and Nel regarded this as a variety of *E. plicatum*, the completely exposed ovary on a long pedicel, the extremely short ovary beak, the growth habit and the fully developed leaves at the time of flowering distinguish it sufficiently as an independent species.
Pauridia longituba Thompson, sp. nov., *P. minuta* (L.f.) Dur. & Schinz affinis, sed perianthii tubo longo et pedicello brevissimo differt.

Cormus globosus, circa 6—7 mm diam., fibris rigidis reticulosis tectus. *Folia* vagina inclusa, glabra, lineari-canaliculata, circa 1 mm lata, flores superans. *Pedunculi* plures, uniflori, breves. *Pedicellus* brevissimus, 0—2 mm longus. *Bracteae* binatae, oppositae, setaceae, inaequales, pedicello longiores, longior ad 10 mm longa. *Flores* regulares, albi; tubus angustus, cylindricus, 8—30 mm longus; segmenta tubo 2—3 plo breviora, ovato-lanceolata, subacuta, interiora quam exteriora paulo parviora. *Stamina* tria, fauce corollae inserta, segmentis interioribus opposita; filamenta brevia, 0,4—1,5 mm longa; antherae basifixae, 1,5—2,75 mm longae; thecis duabus longitudinaliter dehiscentibus. *Ovarium* ovoideum, 3-loculare, placentatione axile, ovulis in quoque loculo multis; stylus perianthii tubo paulo brevior; stigma ad 5 mm longum, trifidum, basi appendicibus tribus parvis. *Fructus* indehiscens, saepe basi foliorum partim inclusus. *Semina* globosa, nigra, nitida, verrucosa.

Type: 3217 **DD** (Vredenburg), shallow soil on granite boulders two miles south of Vredenburg, *Thompson 92* (STE, holo., PRE, NBG).

Corm globose, about 6—7 mm in diam., covered with rigid reticulate fibres. *Leaves* included in a sheath, glabrous, linear-canaliculate, $\pm$ 1 mm wide, overtopping the flowers. *Peduncles* many, one-flowered, short. *Pedicel* very short, 0—2 mm long. *Bracts* two, opposite, setaceous, unequal, longer than the pedicel, the longer up to 10 mm long. *Flowers* regular, white; perianth tube narrow cylindric, 8—30 mm long; lobes spreading $\frac{1}{3}$—$\frac{1}{2}$ the length of the tube, ovate-lanceolate, subacute, the inner slightly smaller. *Stamens* three, inserted in the throat of the perianth-tube opposite the inner segments; filaments short 0,4—1,5 mm; anthers basifixed, 1,5—2,75 mm long, 2-thecous, splitting longitudinally. *Ovary* ovoid, 3-locular, placentation axile, ovules numerous in each chamber; style slightly shorter than the perianth tube; stigma up to 5 mm long, trifid with three small appendages at the base. *Fruit* indehiscent, often partially enclosed in the leaf sheaths. *Seeds* globose, black, shiny, warty.

CAPE—3217 DD (Vredenburg): Witklip farm near Vredenburg, *Thompson 21a* (NBG) *89* (STE, PRE), Vredenburg, *Thompson 92* (STE, PRE, NBG); Paternoster, *Thompson 95* (STE, PRE); Veldrift, *Thompson 290* (PRE); Titosklip, *Axelson 212* (NBG).

The genus *Pauridia* has been variously placed in the Amaryllidaceae and Haemodoraceae and most recently in the Hypoxidaceae as recognized by Hutchinson. Although there are only three stamens which lie opposite the inner perianth segments, in all other aspects *Pauridia* is obviously closely related to the rest of the Hypoxidaceae.

Pauridia longituba differs from *P. minuta*, the only other species in the genus, in having a very long perianth tube (2—3 times as long as the lobes) and virtually no pedicle, leaving the bracts almost adjacent to the ovary.

This species is confined to the shallow soil on granite outcrops in the Vredenburg—Paternoster area. It flowers in winter (May—June) when the hollows in the rocks often contain water.

FURTHER OBSERVATIONS ON THE DISTRIBUTION OF MANGROVES IN THE EASTERN CAPE PROVINCE.

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ABSTRACT

The distribution of mangroves between the Bashee River and East London was investigated. Mangroves were found along the Bashee, Nqabara, Nxaxo, Kobonqaba and Gonubie Rivers. *Avicennia marina* was present at all these localities, while *Bruguiera gymnorrhiza* occurred only at the Bashee and Nxaxo Rivers.

UITTREKSEL

VERDER OPMERKINGS OOR DIE VERSPREIDING VAN WORTELBOME IN DIE OOS-KAAP PROVINSIE.
Die verspreiding van wortelbome tussen die Basheerivier en Oos-Londen is ondersoek. Wortelbome het slegs langs die Bashee-, Nqabara-, Nxaxo-, Kobonqaba- en Gonubieriviere voorgekom. *Avicennia marina* is op al hierdie plekke aangetref, terwyl *Bruguiera gymnorrhiza* slegs by die Bashee- en Nxaxoriviere gevind is.

INTRODUCTION

Several workers have pointed to the decreasing occurrence and importance of mangroves along the eastern Cape coast. This community was described as well-developed at the Bashee River and as reaching its southern limit near East London (Muir, 1937; West, 1944; Macnae & Kalk, 1962). However, no detailed information was available on the distribution of mangroves in the area between these points. From time to time the writer received vague reports of mangroves along certain rivers in this area.

An intensive survey of the rivers in the districts of Willowvale, Kentani, Komga, and East London was undertaken to provide a more complete picture of the distribution of mangroves. With the exception of the Mendu River, all the larger rivers in the area between East London and the Bashee River were examined (Fig. 1). In most cases the rivers were examined on foot for a distance of approximately 3 km upstream from the mouth. Where it was not possible to examine both banks along the entire length, the opposite bank was scanned carefully through 10×50 binoculars. Although for several years previously the writer has conducted sporadic surveys of some of the rivers in this area, intensive surveys were conducted in January, July and December.
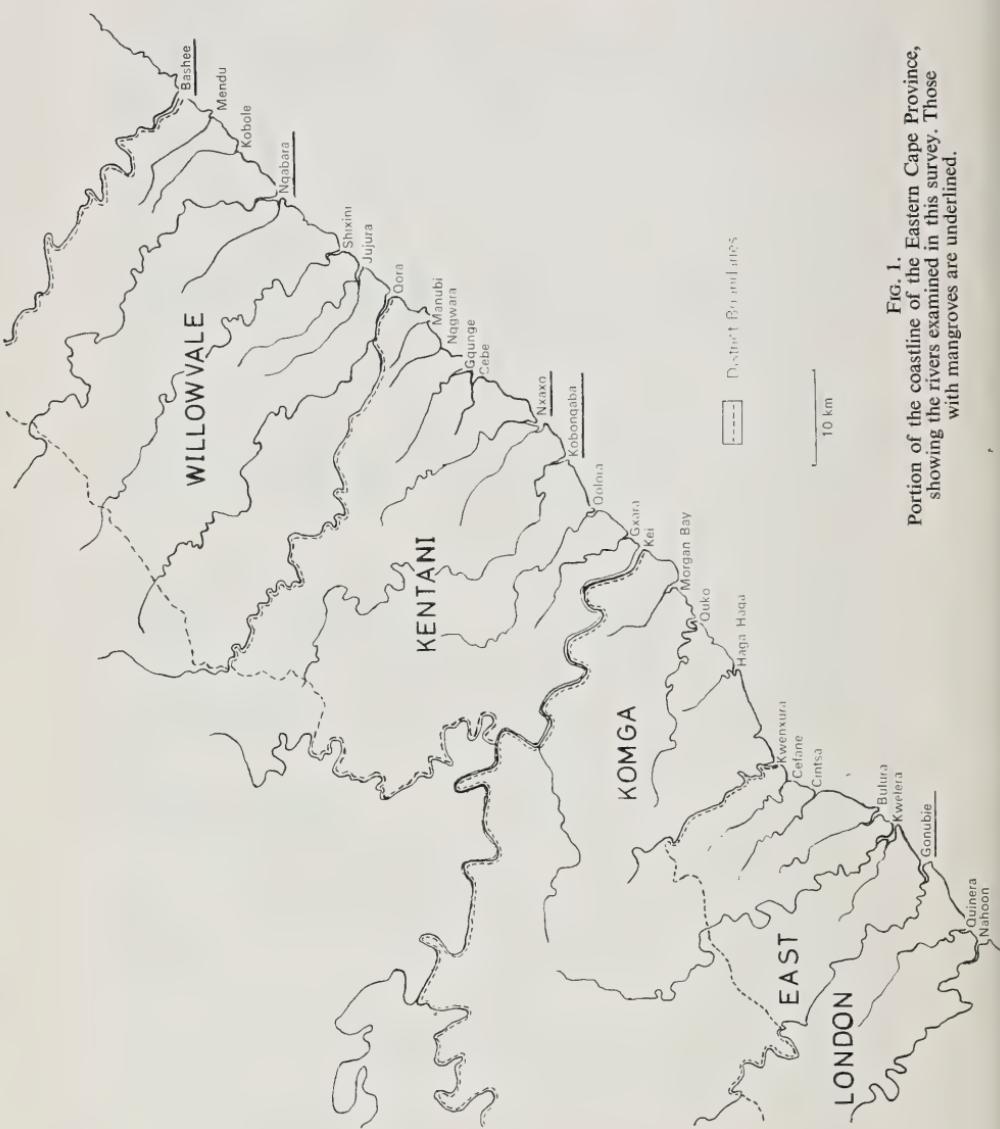
Fig. 1.
Portion of the coastline of the Eastern Cape Province,
showing the rivers examined in this survey. Those
with mangroves are underlined.

1969, and January, 1970. Most rivers south of the Kei River and in the southern part of the Willowvale district were visited twice during this period.

The objects of this survey were mainly to establish the presence or absence of mangroves along these rivers, the approximate extent and species composition of the stands, and the condition and regeneration of the mangroves. This survey has indicated the local importance of mangroves along certain rivers in the southern Transkei and their almost complete absence south of the Kei River.

Avicennia marina

Bruguiera gymnorrhiza

Rocks

1 km
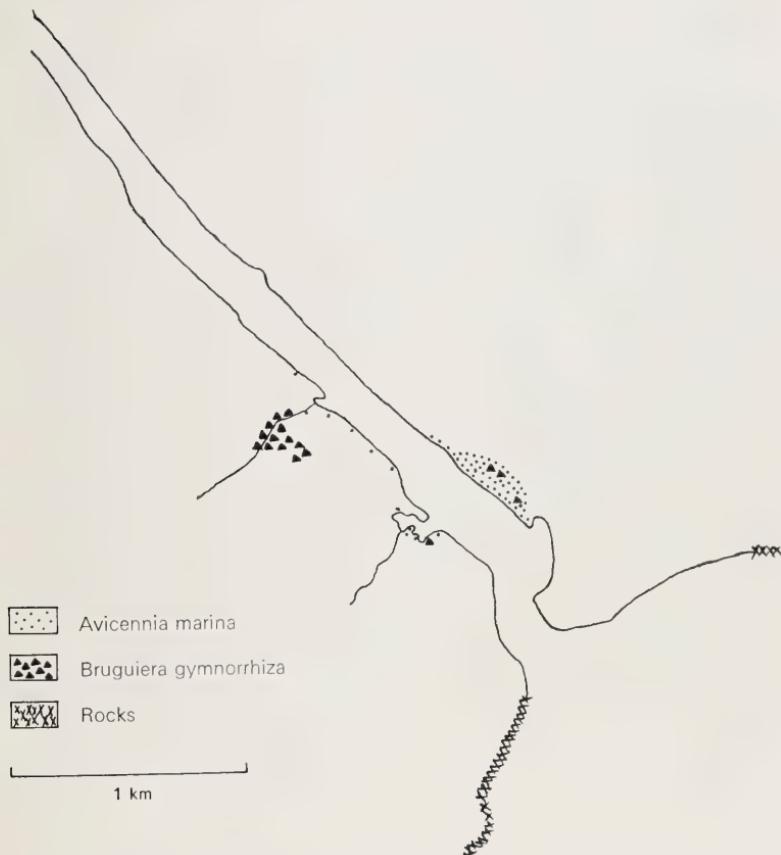
FIG. 2.
Distribution of mangroves along the Bashee River.

DISTRIBUTION OF MANGROVES

Mangroves were found only along the Bashee, Nqabara, Nxaxo, Kobonqaba, and Gonubie Rivers. The distribution of mangroves along these rivers is shown in Figs. 2—6.

This river, which formed the northern limit of the survey, was visited on 23/1/70. With the exception of a slight curve at the mouth, the river is straight for a distance of 3,5 km upstream. Both banks are fairly flat and extensive mudflats are present near the mouth. Among local inhabitants the river is noted for its frequently muddy colour which suggests that silt deposition must be significant at the mouth.

Although he did not visit them, West (1944) reported the presence of a large stand of *Bruguiera gymnorrhiza* on the southern bank. This stand was, in January 1970, not so extensive and the surviving trees were in poor condition. The presence of stumps indicated that a large number of trees had died in that part of the stand nearest the river. It was obvious that even trees of moderately large size had not escaped; relics of trees of 6—7 m in height were seen. The reasons for this mass mortality were not evident, although it is suggested that heavy depositions of silt and consequent covering of the base of the trees were a factor. It did appear as if the level of the bank had been raised. This is probably also the reason for the unhealthy appearance of the remaining trees, the tallest of which were only 4 m. Apparently the river seldom, if ever, reaches these trees nowadays. This was borne out by the ground vegetation which consisted chiefly of *Stenotaphrum secundatum*, *Juncus kraussii*, *Cynodon dactylon* and *Phragmites australis*.

On mudflats nearer the river scattered trees and saplings of *B. gymnorrhiza* and *Avicennia marina* occurred among ground vegetation consisting chiefly of *Arthrocnemum spp.* and *Sporobolus virginicus*.

The main stand of mangroves was on the north bank. The mangrove community stretched along this bank for a distance of 400 m and was approximately 100 m wide. The trees consisted almost entirely of *A. marina*, the tallest of which were 8 m in height. Clear differences in age could be distinguished among members of this community. The older members were clearly seen from their size and their branching near the base. Apparently they colonized this area 14—20 years ago. The younger trees, which formed a dense growth among the scattered older trees, were upright with no branching low down. The community was well established and had obviously withstood flooding successfully.

Only six saplings of *B. gymnorrhiza* were found scattered among the *A. marina* and, although the tallest was not much more than 3 m in height, they appeared healthy. The larger specimens were flowering.

The ground vegetation consisted mainly of *Arthrocnemum* spp. although *Cotula coronopifolia* and *Triglochin striata* were also common.

Landwards the mangroves gave way to a mixed community of *S. secundatum* and *J. kraussii*. This in turn was succeeded by dune bush with *Hibiscus tiliaceus* along the margin. Upstream the mangrove community passed into the mixed *Stenotaphrum—Juncus* community which occurred in a belt along the bank of the river for several hundred metres.
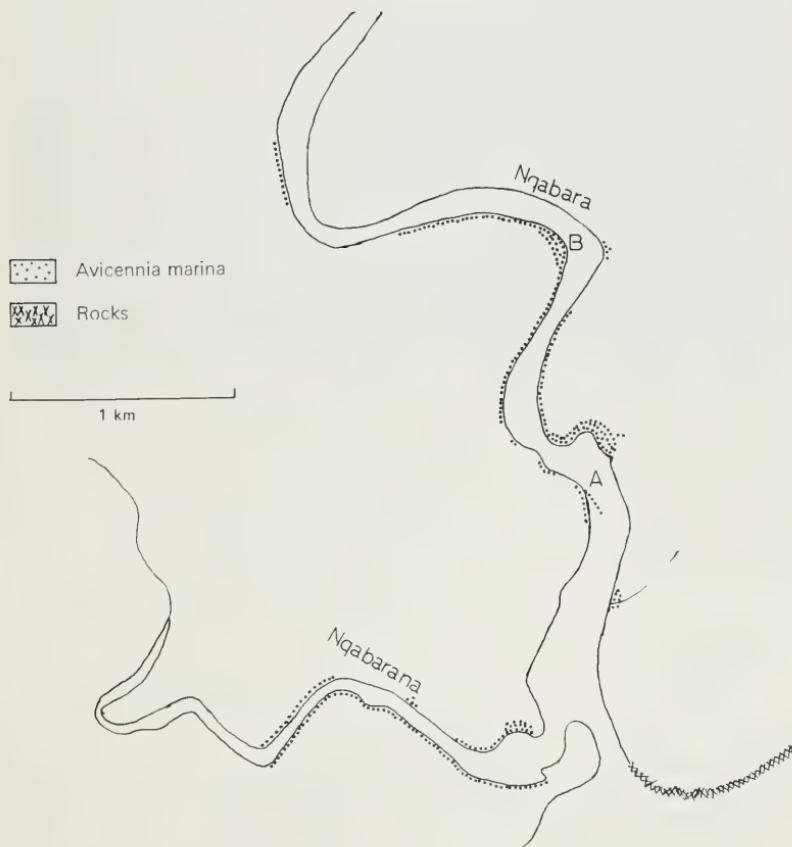
FIG. 3.
Distribution of mangroves along the Nqabara-Nqabarana Rivers.

A few hundred metres from its mouth the Nqabara River is joined by the Nqabarana River. A spit of sand restricted the width of the mouth to approximately 20 m. Apparently poor rainfall during the past few years had resulted in the accumulation of sand at the mouth, causing it to become narrower and shallower.

The Nqabara is a wide river which winds gently on its last 5 km to the sea. For approximately 2,5 km from the mouth the north bank rises steeply from the water and is covered with bush broken only where a stream enters the river. On the south bank also the ground rises steeply for a distance of 1,5 km. Thereafter except for a short krantz 4 km upstream on the north bank the banks are fairly flat for a few kilometres.

Along this river *A. marina* occurred on the mudflats on both banks. The stand furthest from the mouth occurred on the south bank approximately 4,5 km upstream, although isolated plants were seen further upriver. While the trees extended further up the river from the mouth on this south bank, they were confined to a narrower belt than on the north bank. On the latter bank the first well-developed community occurred at A (Fig. 3) where the stand was about 25 m wide. This tapered to a belt 10 m in width and finally to only a single row of trees lining the bank. The tallest trees were 8 m in height, but towards the end of their distribution they were much shorter (3—4 m).

In addition to the continuous stand, small pockets of trees occurred in patches on mudflats below the krantzes wherever a stream entered the river. Isolated trees also occurred along the base of the krantzes where there were small deposits of mud between rocky outcrops. Although no measurements were possible, it was obvious from their height that they had been growing there successfully for some years.

Flowering was evident on mature trees. Extensive colonization was taking place on both banks at A and on the south bank at B (Fig. 3). The colonization on the south bank at A is interesting because a line of saplings has extended into the river at an angle to the mangroves lining the bank (Fig 4). At low tide these saplings were seen to be growing on the edge of a silt bank which had developed outwards from the main bank.

The ground vegetation along the river banks consisted almost entirely of *Arthrocnemum* spp. In the flatter areas alongside the river maize lands extended almost to the edge of the mangroves.

There seemed to be comparatively few mangroves intermediate in size between those of the newly established patches and the mature trees. Apparently in the past the young plants were killed in some way, leaving only the more mature specimens.

The Nqabarana River is narrower and more winding than the Nqabara. Due to near gale-force winds and rough water on 13/1/70 when this area was

FIG. 4.
Avicennia marina lining Nqabara River with recently-established saplings on alluvial spit at A. View looking towards mouth.

visited, it was not possible to study the distribution of mangroves for any great distance along the Nqabarana River. The distribution recorded on the map for this area (Fig. 3) is based on rough observation on the writer's part and on information obtained from a colleague. The responsibility for any inaccuracies, should they occur, is entirely the author's.

At its junction with the main stream, the Nqabarana River had a small, well developed stand of *A. marina* on the north bank, but this ended where the bank becomes steep. Further along this bank there was a small patch at the confluence of a small stream, otherwise there were no further mangroves until the steep bank is replaced by mudflats. The south bank is fairly flat and supported a continuous narrow belt of *A. marina*.

A common mouth serves these two rivers which were visited on 24/1/70. The mouth is very narrow, only a few metres wide in places, although this closure has been aggravated by droughts in recent years.

At the confluence of the rivers there is a large flat area where the best development of mangroves occurred. In this area the stand was about 100
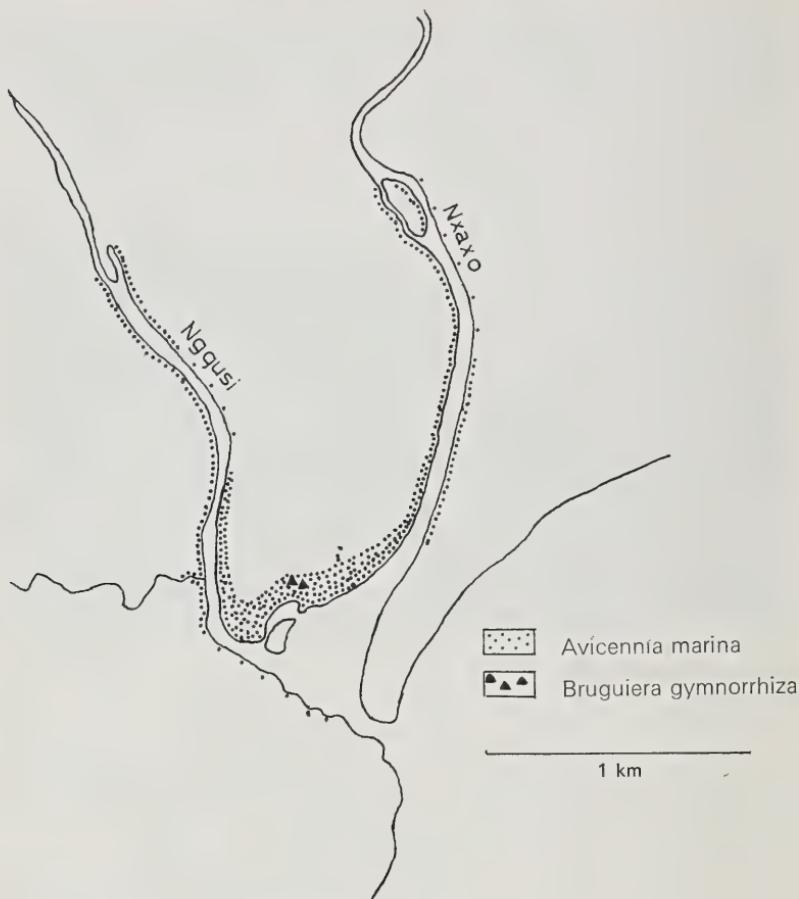
Fig. 5.
Distribution of mangroves along the Nxaxo-Nqusi Rivers.

metres wide and consisted mainly of *A. marina*. These varied in size from plantlings to trees 7 m in height. The community appeared healthy and flowering was evident on the more mature specimens. The proprietor of the local boarding-house confirmed that there had been an increase in the stand during the past ten years. A few young trees of *B. gymnorrhiza* also occurred, but they were generally scattered except for one small community towards the inland edge

of the stand. The tallest tree was 4 m in height and had well-developed knee roots. Developing fruits were present on the bigger specimens.

From this confluence the stand tapered to a narrow belt along the rivers. *A. marina* was the only mangrove lining the rivers' banks.

The distribution along the Nxaxo River was mainly along the south bank. Here the stand narrowed gradually to a belt which was 20 m in width for most of its length and finally gave way to isolated trees. As the stand narrowed the trees became shorter and at the extremity they were only 1—2 m in height. Among the mangroves the ground vegetation consisted almost entirely of *Arthrocnemum* spp. On the landward edge of the community the vegetation was variable due to disturbance for the cultivation of maize, but generally there was a narrow belt of *Phragmites australis*, *Juncus kraussii*, and *Stenotaphrum secundatum* between the mangroves and the lands. Along the north bank there was one short belt of trees with only isolated scrubby specimens further upstream.

Along the Nqusi River the mangroves occurred as a narrow continuous belt on the south bank, but were generally scattered along the north bank. At the extreme end of their distribution the belt had narrowed to only a single line of trees which were scrubby (1—2 m in height).

There were few big trees in evidence in this area. This is believed to be due to the extensive chopping of larger trees by local Africans for use mainly in the construction of kraals. There was frequent evidence of chopping having been carried out in the recent past. Obviously *A. marina* in this area can grow fairly large if left undisturbed. In an inaccessible part along the Nqusi River a tree of height 8—10 m was observed whose stem diameter measured 48 cm at a height 1 m from the ground (below the branching main stem).

This appears to be the southernmost river on which an extensive stand of mangroves occurs in South Africa. The Kobonqaba River is the largest of the rivers within the Kentani district, and although the mouth has in recent years become narrower and shallower, it has never closed. *A. marina* was the only mangrove observed.

The main distribution was along the south bank. The tallest trees were 7 m in height. Near the mouth only occasional trees were found, but from about 1 km upstream there was a continuous belt, at first fairly wide although narrowing towards the extremity. Here the stand was only 10 m wide and the plants scrubby. On both banks of a small tributary there was a well developed stand. The community appeared to be healthy and regeneration was evident. The ground vegetation consisted almost entirely of *Arthrocnemum* spp.

Along the north bank mangroves occurred in only two patches. The larger of these occurred as a fringe along the river and measured 20 m at its widest point. The tallest tree was 7 m in height although the stumps of specimens
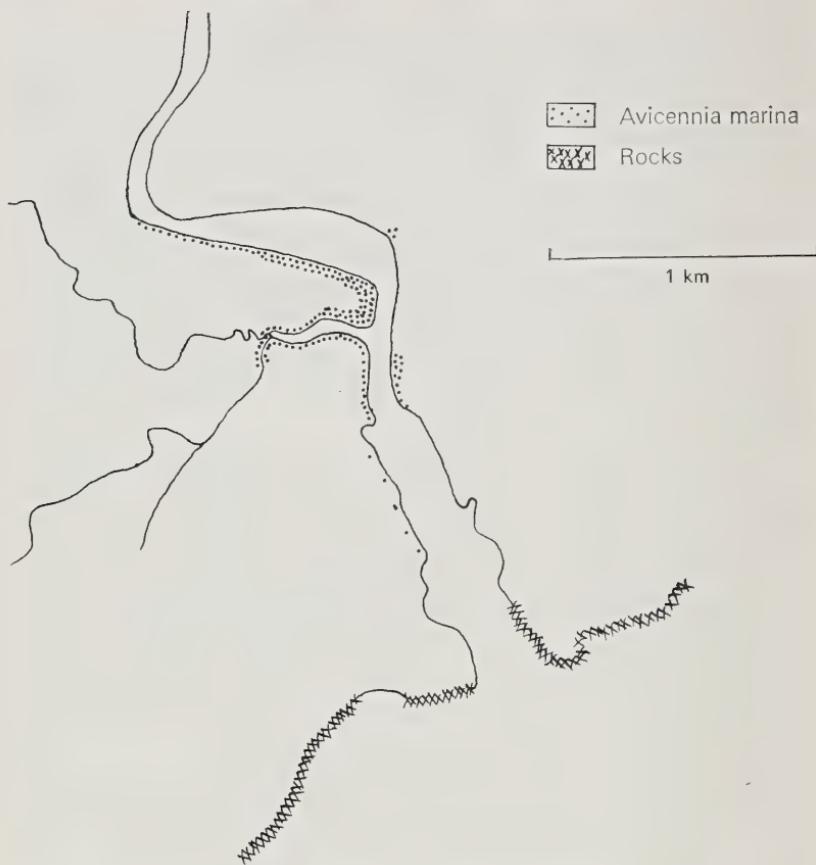
FIG. 6.
Distribution of mangroves along the Kobonqaba River.

which could have been even taller were found. One stump measured 26 cm in diameter, at a height of 0,66 m from ground level. Flowers were present on the older trees. Active regeneration was obvious from the presence of young trees. Again *Arthrocnemum* spp. formed the only ground vegetation. The other patch along this bank was not examined carefully, but it occurred apparently where a rivulet joined the main stream.

Along this river chopping had clearly been carried out fairly extensively.
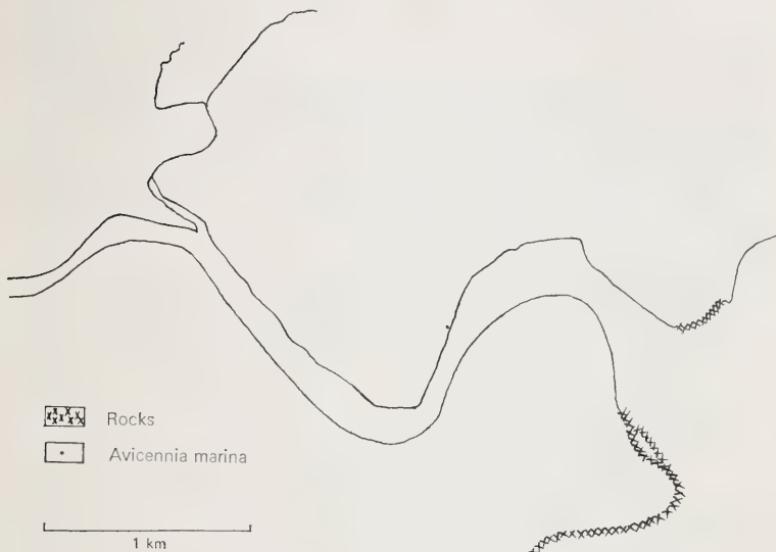
FIG. 7.
Distribution of mangrove along the Gonubie River.

South of the Transkei this was the only river along which any mangrove was found. The Gonubie River is one of the larger rivers in the East London district and reaches the sea in a series of gentle curves near the mouth. There is a rocky projection into the sea just south of the mouth which is fairly wide and has never been known to close. The south bank of the river is steep and rocky for approximately 2,5 km upstream. The opposite bank is dominated by a krantz which gives way to mudflats almost 1 km from the mouth.

On 19/12/69 these mudflats were visited and at about high-water mark a single specimen of *A. marina* was found growing among *Arthrocnemum* sp. The plant was branched low down and just over 1 m in height. The furthest pneumatophore was at a distance of 50 cm from the main stem. Although there was no sign of flowering, the plant looked healthy.

DISCUSSION

The results from the survey area have confirmed that mangroves are of negligible importance south of the Kei River, while north of this mangroves are absent from only two of the larger rivers (i.e. Shixini, Qora) which are open permanently. Information collected further north between the Bashee

and Umzimvubu Rivers suggests that mangroves are more numerous than one might expect.

In the S.E. Cape Province there are many smaller rivers which are open to the sea but only irregularly so or for relatively short periods. Most of the rivers in this area appear to fall into this category. Although these were included in the survey, no mangroves were found. Along many of these rivers there are fairly extensive mudflats which would seem to provide suitable conditions for the establishment and growth of mangroves. Their absence can probably be ascribed largely to the following factors:

(a) These rivers are open for relatively short periods which may not coincide with the time of arrival of propagules.

(b) When the mouth does open, there appears to be a net outflow of water, and this increases the odds against any propagules entering the river while it is open to the sea.

(c) With this net outflow the level of the river falls until the mouth becomes closed once more. Over the succeeding months, seasons, or even years, the level gradually rises again as a result of rains or inflow from tributaries, until the river is high enough to flow into the sea again. Propagules entering the river would do so at its low level and any seedlings which may become established would probably be drowned as a result of continuous submersion under the rising waters of the river.

(d) When these rivers do open to the sea the mouth is usually very narrow, which must limit the chances that propagules will be able to enter the river.

(e) The number of propagules reaching the more southerly parts of the survey area is undoubtedly low.

On the other hand, there are several rivers which remain open permanently, which have fairly extensive mudflats, and yet have no mangroves. Examples are the Shixini, Kei, Kwelera, and Nahoon Rivers. Although there was a report of *Bruguiera gymnorrhiza* along the Kei River (Muir, 1937), no mangroves were found after an exhaustive search along both banks for a distance of almost 4 km upstream. On both banks there are mudflats, although they are more extensive on the north bank. Here the vegetation comprises mainly *Arthrocnemum* spp., *Sporobolus virginicus*, and *Triglochin striata*.

Along the north bank the Kwelera River has a wide, long mudflat which extends for approximately 2 km upstream. *Arthrocnemum* spp. and *Limonium scabrum* are the main constituents. The relatively narrow mouth of this river probably limits the chances of mangroves being established here. Although conditions along the Qora River are not really suitable for the establishment of mangroves, those along the Shixini River are, and the presence to the north

of several rivers supporting well-developed stands of *A. marina* (viz. Nqabara, Bashee, Xora) makes its absence more surprising.

The reasons for the almost complete absence of mangroves in the Ciskei are also not clear. In Australia and New Zealand mangroves (*A. marina*) are found at a lower latitude and under cooler conditions than in South Africa. Furthermore, there is a good development along the Nxaxo and Kobonqaba Rivers where climatic conditions are unlikely to be significantly different from those near East London. This suggests that temperatures of the order experienced in the S.E. Cape are not of prime importance in limiting distribution. During December, 1969, the writer transplanted six *A. marina* seedlings from Durban Bay on a mudflat on the north bank of the Nahoon River. The object was to measure their growth subsequently at regular intervals and to compare these results with similar measurements in Natal and in growth cabinets. The seedlings were approximately 20 cm tall at the time of planting. In December, 1970, the area was revisited and not only had two survived the worst recorded floods in East London's history, but also their growth in that year had been significant. The larger tree had reached a height of 30 cm and appeared healthy. In this area a seedling from a previous transplanting had survived a silt deposition of approximately 15 cm from these floods. These preliminary results and the condition of the sapling at Gonubie indicate that growth of *A. marina* is fairly good near East London and support the contention that unfavourable climatic conditions cannot be regarded as the main factor responsible for its absence in this region. It is suggested that the reasons for the absence of mangroves must also lie in the paucity of propagules and possibly unfavourable ocean currents (Macnae, 1962).

Several reports were received of the occurrence of mangroves along some of the other rivers in this area, the southernmost "find" being apparently *B. gymnorrhiza* at Mcantsi River, near Kidd's Beach. All these reports were investigated, but no further mangroves were seen. In fact, it is extremely unlikely that mangroves could ever have occurred at some of these places.

There is no evidence that mangroves in recent times were more widespread in this area than they are now. It is possible that along some of the rivers an occasional seedling might have become established only to be destroyed soon afterwards. The absence of trees in other estuaries supports this view. Had any tree grown to maturity there would probably be some evidence of its existence now. The occurrence of several seasons of low rainfall before the survey would have favoured the establishment of seedlings. Prior to the survey, heavy rains were experienced in this area during autumn, 1963, and it is thus unlikely that any seedlings which reached these parts subsequently would have failed to have established themselves due to flooding. The recent experience at Nahoon sug-

gests that even the 1963 rains would probably not have affected young trees or seedlings.

However, observations during the next few years may reveal a more wide-spread distribution to be taking place. Reports of rivers with mangroves have indicated their increase during the past 10—15 years. Many of these trees will have already reached or will soon reach a reproductive stage. If this increased production of propagules occurs at a time when river mouths have been opened up by good rains, then a spread of mangroves to previously uncolonized areas could well result. Reference has already been made to the community along the Nqabara River where only old and young trees appear to be present. This suggests that in some way destruction of the younger members of the community occurred in the past. If this is a phenomenon which occurs periodically, then the same fate may befall the present developing communities in this area, with a consequent reduction in production of propagules and no further increase in distribution. If, however, this can be shown over the next few years to be not so, then in fact we may be observing a part of our vegetation still in the process of its southward migration.

Reference has already been made to the extensive chopping of larger trees along some rivers in the Transkei. Obviously some effective measure of control must be exercised if these important southernmost communities are to survive in a healthy condition.

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A NEW SPECIES OF *LACHENALIA* FROM THE SOUTH WESTERN CAPE

W. F. Barker

(*Compton Herbarium, Kirstenbosch*)

ABSTRACT

A new species of *Lachenalia*, *Lachenalia viridiflora* Barker is described.

UITTREKSEL

'N NUWE SOORT *LACHENALIA* VAN DIE SUID-WES-KAAP.
'n Nuwe soort *Lachenalia*, *Lachenalia viridiflora* Barker word beskryf.

INTRODUCTION

This species is extremely local and as far as is known only occurs in the Vredenburg district, where a number of collections have been made. The type material was collected in June 1964 and a further extensive collection was made in the type locality in June 1965. Seed was later distributed to several countries including New Zealand, where it has been successfully cultivated for several years under the manuscript name *Lachenalia viridiflora* Barker.

Lachenalia viridiflora Barker sp. nov. affinis *L. reflexae* Thunb., sed floribus viridianis insignibus, foliis non reflexis, distinguitur.

Planta 8—20 cm alta, plerumque nana. *Bulbus* depressoglobosus, 1,5—2,5 cm diam., tunicis spongiosis. *Folia* 2, lanceolata vel ovata, adscendens vel patentes, ad 13 cm longa, 3,5 cm lata, plerumque minoria; laete chlorina, immaculata, sed lineae depressae angustae superne aut interdum pustulis vel maculis fuscis supra. *Pedunculus* inflorescentia plerumque breviore; laete viridis; maculatus quandocunque folia maculis sunt. *Inflorescentia* 6—20 floribus, aliquot floribus sterilibus ad apicem versus. *Bracteae* albae, ad 1 cm longae lineares-lanceolatae. *Pedicellus* curtus, 2—3 mm longus. *Flores* 1,8—2,3 cm longi, erecti vel patentes, ventricosi, obliqua basi; tubus 7 mm longus, viridianus; segmenta externa tubo longiora, viridicaerulea, carinis viridianis; segmenta interiora 5 mm longiora quam segmenta externa, apicem versus patentes, candida viridiflava versus centra, stria mediana viridiana. *Stamina* segmenta externa aequantia. *Ovarium* ovoideum, venetum, 4—5 mm longum. *Stylus* postremo exertus.

Fig. 1.
Type locality for *Lachenalia viridiflora*.

Fig. 2.
Habitat of *Lachenalia viridiflora*.

FIG. 3.
Lachenalia viridiflora. Half life size. (Part of type material in cultivation, *W. F. Barker* 10171.)

FIG. 4.
Lachenalia viridiflora, 2 flowers, the upper showing the set of the inner segments at anthesis.
Twice life size. (From type material in cultivation, *W. F. Barker* 10171.)

Plants 8—20 cm high, usually dwarf. *Bulb* depressed globose 1,5—2,5 cm diam. with spongy tunics. *Leaves* 2, lanceolate to ovate, suberect to spreading, up to 13 cm long and 3,5 cm broad, but usually less, bright yellow green without markings but with narrow depressed lines above, or in some plants with dark spots or pustules on the upper side. *Peduncle* usually shorter than the inflorescence, pale green, spotted in plants with spotted leaves. *Inflorescence* racemose 6—20 flowered, with a few sterile flowers at the apex. *Bracts* white, linear-lanceolate up to 1 cm long. *Pedicels* short 2—3 cm long. *Flowers* 1,8—2,3 cm long, erect to spreading, ventricose, oblique at the base; tube 7 mm long viridian green; outer segments a little longer than the tube, pale blue-green with a viridian green keel; inner segments 5 mm longer than the outer, spreading slightly at the tip at anthesis, shining white, shading to yellow green toward the centre with a viridian median stripe. *Stamens* as long as the outer segments. *Ovary* ovoid, blue green, 4—5 mm long; style finally exserted.

Diagnostic Characters: Lachenalia viridiflora is most closely allied to *Lachenalia reflexa* Thunb., having a ventricose perianth with a comparatively long tube, oblique at the base. It is distinguished from it by the bright viridian green colour of the flowers, which are more open at the mouth at anthesis and the leaves which are not distinctly reflexed. *Lachenalia viridiflora* only occurs on granite boulders in rock pans and crevices where a great deal of humus has collected, while *Lachenalia reflexa* occurs on open flat sandy ground.

Type Material: Vredendal district, Witklip Farm, in rock pans and crevices on huge granite boulders, 16/6/1964, *W. F. Barker* 10171, holotype (NBG, isotypes PRE, BOL, K).

Specimens Examined:

CAPE PROVINCE—3217 (Vredenburg): Witklip Farm, Vredenburg, in rock pans on granite boulders (–DD), 16/6/1964, *W. F. Barker* 10171 (NBG, PRE, BOL, K); Witklip Farm in rock pans on granite boulders (–DD), 7/6/1965, *E. G. H. Oliver* STE 31, 118 (NBG, PRE, STE, BOL, K); Steenberg Cove in rock crevices (fruiting) (–DB) 23/8/1953, *H. Hall* 742 (NBG); Stompneus on rocks near sea (flowering) (–DB), 28/6/1955, *H. Hall* 754 (NBG); Hill above Steenberg Cove, on huge granite boulders in crevices and rock pans, (–DB), 3/6/1970, *W. F. Barker* 10684 (NBG, PRE).

Discussion

In the type locality, which consists of a huge granite boulder somewhat isolated from other similar formations in the area, the plants were found growing massed together in large numbers in rock pans and crevices where large quantities of humus and animal manure had accumulated. All the plants seen and collected had plain green leaves and peduncles without any visible spotting. The flowers which were erect in the bud stage, tended to spread at anthesis and later to become erect again. Plants collected on granite boulders near the sea at Steenberg Cove and Paternoster on the other hand, tended to be more scattered and more dwarf with fewer flowers. In the majority of specimens seen the leaves were

distinctly marked with dark spots or pustules on the upper surface, and the flowers tended to be more vivid in colour, smaller, and remained more erect than those of the plants from the type locality, however a few plants were found without any spotting or marking whatever, linking what at first had appeared to be two distinct local forms.

TWO NEW SPECIES OF *ALOE* (LILIACEAE) FROM ZAMBIA

L. C. LEACH

ABSTRACT

Two new species of *Aloe* from Zambia are described, their apparent relationships discussed and their positions in the "Key to the species" in Reynolds, *The Aloes of Tropical Africa and Madagascar* (1966), are indicated.

UITTREKSEL

TWEE NUWE SOORTE *ALOE* (LILIACEAE) VANAF ZAMBIA

Twee nuwe soorte *Aloe* vanaf Zambia word beskryf, hulle blykbare verwantskap bespreek en hul plek in die „Sleutel tot die soorte" in Reynolds, *The Aloes of Tropical Africa and Madagascar* (1966) word aangedui.

Aloe luapulana Leach, sp. nov.; ad *A. christianii* Reyn. affinis sed planta parviore semper acaulescentes, rosula foliorum parviorum; tardius florenti, inflorescentia breviore infra medium ramosa, racemis brevioribus laxius florentibus floribusque brevioribus basaliter inflatis differt.

Plantae acaulescentes, solitariae. *Folia* c. 16, rosulata patentia, ovato-attenuata, c. 30 cm longa (ubi ambrosa ad 55 cm), basi 6—7,5 cm lata, plerumque parte apicali siccata marcidaque (usque ad $\frac{2}{3}$ per totam longitudinem), succo sicco flavido; *supra* pallide viridia, obscure striata, apicem et marginem versus purpureo-brunnescentia, basi leviter concava; *subtus* pallide griseo-viridia, distinctius striata; *margines* cartilaginei, exalbidi, dentibus deltatis pungentibus 1—3,5 (5) mm longis, parvis confertis basin versus, grandioribus, 15—18 (25) mm distantibus apicem versus. *Inflorescentia* paniculata, infra medium ramosa, c. 110 cm alta. *Pedunculus* brunneus, plus minusve teres vel perleviter compressus prope basin, c. 1,0 cm diam. *Racemi* erecti, laxe floriferi, cylindraceo-acuminati, 16—26 cm longi, c. 6 cm diam., coma parva sicca ornati, gemmis patulis floribusque apertis cernuis. *Bracteae* ovatae, acutae, scariosae exalbidae, 4—5 mm longae, c. 3,5 mm latae, nervis brunneis 4-5. *Pedicelli* patuli, c. 7,5 mm longi. *Perianthium* coralloides ad orem flavescens, haud stipitatum, 29—33 mm longum, ad basim truncatum inflatum 8—9 mm diam. inde ad 5 mm decrescens, cylindraceo-trigonum, leviter lateraliter compressum; *segmenta exteriora* per 12—16 mm libera, obscure triplinervia; *interiora* latiora, leviter carinata, apice obtusiora patentiora, minutissime denticulata. *Antherae* ad 6 mm exsertae. *Ovarium* viride, obtusissime trigonum, 6—7 mm longum, c. 2,5 mm diam. *Stylus* demum ad 3,5 mm exsertus.

Specimens Examined:
ZAMBIA (N): Luapula Distr., Luongo Riv., on rocks above Masonda Falls, $\pm$ 1230 m alt., $\pm$ 56 km N of Mansa, cult. Lusaka, fl. Sept. 1969, *G. Williamson* 1738 (SRGH); Mansa, termite mound near aerodrome, $\pm$ 1240 m alt., cult. Salisbury, fl. Sept. 1970, *P.A.G. Weeks* 1 (BR; SRGH, in liquid), idem, fl. Aug. 1971, sub *Leach* 14754 (PRE; SRGH), plant in tree shade. 14754B (K; PRE; SRGH), 14754C (K; MO).

This new species from the *Flora Zambesiaca* area appears to be most closely related to the widely distributed *A. christianii*, and in rosettes of pale green obscurely striate leaves the resemblance is very close indeed, although plants of the new species are much smaller than the average for *A. christianii*. The difference in size becomes even more evident when plants flower, as the inflorescence of *A. luapulana* averages only about 1 m in height, in contrast to the 2—2,75 m of that of *A. christianii*, and is branched at, or mostly, well below the middle, while that of its relative branches well above that level. However, the most important difference lies in the shorter more laxly flowered racemes of the new species and in its shorter flowers which are noticeably inflated at the base. All other species in this apparently closely related group have flowers which are either more or less straight or somewhat tapered from the base; included here, in addition to *A. christianii*, are *A. pretoriensis* Pole Evans, *A. guerrae* Reyn. and although slightly less close in some respects *A. crassipes* Bak., *A. trigonantha* Leach and probably *A. steudneri* Schweinf. Finally the new species flowers in late August/September as compared with the usual May/June flowering period for *A. christianii*.

A. luapulana is known only from the type locality near Mansa (Fort Rosebery) where plants collected by Mr. P. A. G. Weeks appeared to be restricted to a termite mound near the aerodrome, and from Masonda Falls· on the Luongo River, a tributary of the Luapula River, here plants found by Dr. G. Williamson were growing on rocks above the falls, in a very humid situation in association with *Aloe mzimbana* Christian, a shrubby euphorbia and several orchids. This latter locality lies about 150 km south of Lake Mweru and some 8 km only from the Congo border to the west of Lake Bangweulu; it seems probable therefore, that the distribution of the new species will be found to extend into that territory also.

Plants acaulescent, solitary. *Leaves* about 16, rosulate, spreading, ovate attenuate, $\pm$ 30 cm long (in shade up to 55 cm), 6—7,5 cm wide low down, usually with the apical two thirds or more, dry and twisted, the sap dries yellow; *upper surface* pale green, obscurely striate, tinged purplish brown towards the apex and margins, slightly concave low down; *lower surface* greyish green, more clearly striate, tinged purplish towards the apex and margins; *margins*

narrowly cartilaginous, whitish, armed with ± deltate pungent teeth, 1 3,5 (5 in shade) mm long, whitish at the base brownish orange at the apex, smaller and more crowded below, 2—5 mm apart, with the interspaces usually somewhat rounded, becoming larger and more widely spaced above, 15 18 mm (25 in shade) apart with the interspaces usually ± straight. *Inflorescence* a branched panicle, 110 cm high (105–120), branched below the middle with 6 simple, spreading arcuate-ascending branches, each subtended at its base by a whitish, scarious bract with many dark brown nerves and with a few sterile bracts below the raceme. *Peduncle* terete, not or only slightly compressed low down, then about 1,0 cm diam., brown with a slight bloom and numerous minute whitish flecks. *Racemes* erect, laxly flowered, cylindric acuminate, 16—26 cm long, the terminal longest, with a small dry coma at the apex, with the buds greyish pink, grey at the apex, spreading, becoming almost immediately ± horizontally so, with the pedicels spreading and the open flowers cernuous to pendulous. *Bracts* ovate acute, scarious, whitish, with 4–5 dark to red-brown confluent nerves, 4—5 mm long, ± 3,5 mm wide. *Pedicels* the colour of the perianth, ± 7,5 mm long. *Perianth* coral-red with a slight bloom, becoming yellowish at the open mouth, cylindric trigonous, slightly laterally compressed, not at all stipitate, truncate or slightly depressed at the inflated base, 29—33 mm long, averaging 30 mm, 8—9 mm diam. across the ovary, thence tapering (not sharply constricted as in *Saponariae*) to ± 5 mm diam. (slightly wider in side view); *outer segments* free 12—16 mm with 3 obscure brownish nerves confluent at the paler coloured spreading apices; *inner segments* themselves free but dorsally adnate to the outer, red with broad whitish margins, orange to orange-brown inside at the more obtuse more spreading apices, with a slightly raised keel with 3 reddish nerves more or less confluent at the very minutely denticulate apex. *Filaments* filiform flattened, faintly pinkish at the base becoming yellow towards the apex, the 3 inner narrower and lengthening before the three outer; anthers dark tangerine, exserted ± 6 mm. *Ovary* bright green, 6-grooved, very obtusely trigonous, 6—7 mm long, ± 2,5 mm diam., tapering slightly towards the apex; *style* straw coloured at the base becoming paler above, at length exserted ± 3,5 mm; *stigma* white.

A. luapulana would 'Key out' in *Reynolds, Aloes of Tropical Africa and Madagascar:* 183 (1966), under Group 12, but is distinguished by its shorter, basally inflated flowers and additionally from *A. trigonantha* Leach by its shorter pedicels and unspotted leaves.

Aloe enotata Leach, sp. nov.
?*Aloe veseyi* Reyn., Reynolds, Aloes Trop. Afr. Madag.: 168 (1966), pro parte quoad loc. Kambole Escarpment.

Flowering Hort. Weeks. Ht. 1,1 m.

Lateral raceme.

Flowers 1 : 1
FIG. 1.
Aloe luapulana Leach.

A. veseyi Reyn. affinis sed planta robustiore, foliis enotatis; bracteis parvioribus; floribus rubris trigono-indentatis basi inflatis, stigmate incluso antherisque non vel vix exsertis bene distincta; racemis floribusque ad *A. chabaudii* Schonl. accedens sed habitu et foliis falcatis statim dignoscenda.

Planta scopulis dependens; caule simplici, usque ad 60 cm longo, 3 cm diam., interdum surculis e basi exilientibus; foliis c. 12, rosulatis. *Folia* 45—60 cm longa, basi 5—6 cm lata, valde patula deorsum versus valde falcata; *supra* plana vel leviter concava, pallidula viridia, subrosea suffusa, praesertim versus apicem et margines, haud notata; *subtus* convexa quam supra pauxillum dilutiora; *margines* angustissimi, cartilaginei, acuti, exalbidi, dentibus parvis dissitis plerumque prorsum uncinatis, interstitiis 20—40 mm longis, plus minusve rectis. *Inflorescentia* pendula, laxe paniculata, c. 85 cm longa, infra medium ramosa, inter ramos leviter flexuosa; *pedunculo* 32 cm longo, brunneo, descendenti gracili tereti, basi leviter compresso, c. 1 cm lato angulis acutis; inflorescentiae ramis 6, bracteis amplectentibus binis, inaequalibus, exalbidis basi indutis; racemis plus minusve horizontaliter patulis leviter ascendentibus vel arcuato-ascendentibus. *Racemi* aliquantum laxe floriferi, cylindraceo-acuminati, 14—20 cm longi, c. 7,5 cm diam., gemmis patulis floribusque apertis leviter cernuis. *Bracteae* plus minusve ovatae acutae, c. 4 mm longae, 3 mm latae, scariosae exalbidae, nervis 3 atrobrunneis. *Pedicelli* patuli brunnei, usque ad 17 mm longi. *Perianthium* rubiginosum, 25—28 mm longum, basi plus minusve obtuse obconicum, circum ovarium ad 8 mm diam. inflatum, supra ovarium sigillatim trigono-indentatum, inde ad c. 5,5 mm diam. angustatum, infra orem apertum ad 6,5 mm diam. gradatim dilatatum; *segmenta exteriora* per 6—8 mm libera, nervis 3 rubris, fere vel satis ad apicem confluentibus; *interiora* latiora, breviter leviter carinata, nervis 3, obscuris confluentibus, marginibus latissimis albidis, aliquantum aurantiacis versus apicem brunneum. *Filamenta* citrina; *antheris* testaceis non vel vix exsertis. *Ovarium* olivaceum basi subtruncatum c. 2,5 mm diam., 5 mm longum, apice obtusum c. 1 mm diam. *Stylus* citrinus; *stigma* exalbida inclusa. *Semina* plus minusve trigona, memnonia alis exalbidis tenuis angustis instructa, c. 5 mm longa, 2,25 mm lata.

Type Material: Zambia, Abercorn Distr., Kambole escarpment, *Richards* sub *Leach* 14796 (K; SRGH, holo.).

Specimens Examined:
ZAMBIA (N): Abercorn Distr., Kambole escarpment, ± 40 km W of Mpulungu, cult. SRGH 5693, fr. Aug. 1970, fl. 10.vii.1971, *Mrs. H. M. Richards*, s.n. sub *Leach* 14796 (K; SRGH), idem cult. Umtali, fl. July 1969, sub *Cannell* 62 (PRE).

The new species appears to have been collected only by that most indefatigable of collectors: Mrs. Mary Richards, whose gatherings from this part
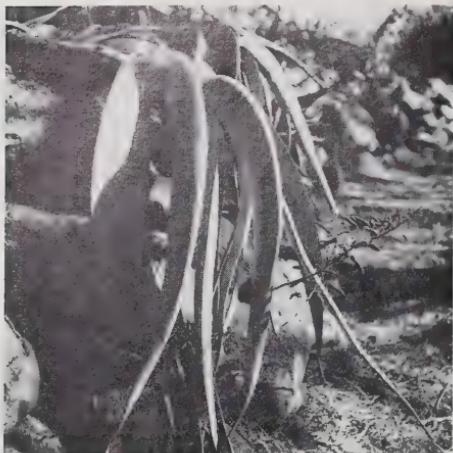
FIG. 2.
Aloe enotata Leach. Plant flowering at Umtali. *Cannell* 62. Photos: Mr. I. C. Cannell.

of Africa are unlikely to be surpassed. Plants collected at Kambole were placed in cultivation at Mbala (Abercorn) and gradually found their way into collections in Rhodesia. The species was however, reluctant to flower and it was not until one or two larger specimens were obtained from Mr. Morony of Mbala, and brought to Salisbury by Mr. R. B. Drummond and Dr. G. Williamson, that material adequate for the description of this interesting new species eventually became available.

Plants collected at Kambole by Mrs. Richards were referred to *A. veseyi* by the late Dr. Reynolds *l.c.;* from the locality it seems probable that these may have been specimens of *A. enotata*, but there is an element of doubt since neither red flowers nor unmarked leaves are mentioned in connection with *A. veseyi* and unfortunately no specimen was cited from this locality. However, there are numerous "good" characters separating the two taxa and it is considered that they probably constitute an excellent example of a vicariant pair.

Fig. 3.
Aloe enotata Leach. The inflorescence of the type plant. Cult. SRGH. Photo: L. C. Leach

A. enotata differs from the Kalambo Falls plants in being more robust, with completely unmarked decidedly pinkish leaves, while the inflorescence is distinguished by its smaller bracts and red flowers which are basally inflated and trigonously indented above the ovary, with the stigma included and the anthers not or scarcely exserted. There is also a difference in the ovary shapes, that of the Kambole plants being subtruncate at the base which is broadly fused to the thick fleshy base of the perianth, and then relatively steeply tapered to the rather small obtuse apex, while that of *A. veseyi* is more nearly ovoid. It is also believed that the capsule of the new species will prove to be larger and differently shaped; unfortunately, owing to the paucity of material available, it has not been possible to confirm this. Finally the seeds of the two taxa,

although very similar, do differ slightly; those of *A. veseyi* being somewhat more brownish in colour and more densely marked and speckled (more definite comparisons are here also, hampered by shortage of material). The seeds of both species are very similar to those of *A. chabaudii* but quite different from those of *A. mendesii* Reyn., a similarly pendent species from S. Angola with similar falcate leaves.

Not a great deal is as yet known about fruit and seed characters of the genus, but it does seem possible that the characters involved may well prove to be of some significance in the classification of *Aloe*, and for that reason are mentioned here.

In trigonously indented perianth and shape of racemes *A. enotata* appears to have a somewhat more distant connection with the group containing the widespread and extremely variable *A. chabaudii;* in fact its inflorescence appears to be almost directly comparable with that of plants of the latter species which are to be seen hanging on cliffs at Victoria Falls on the Zambesi River. However, in most other respects these taxa are quite different. It should also be mentioned that there is a tendency for similarly but less markedly indented perianths to occur in *A. veseyi*, thereby, it seems, confirming its close relationship with *A. enotata*.
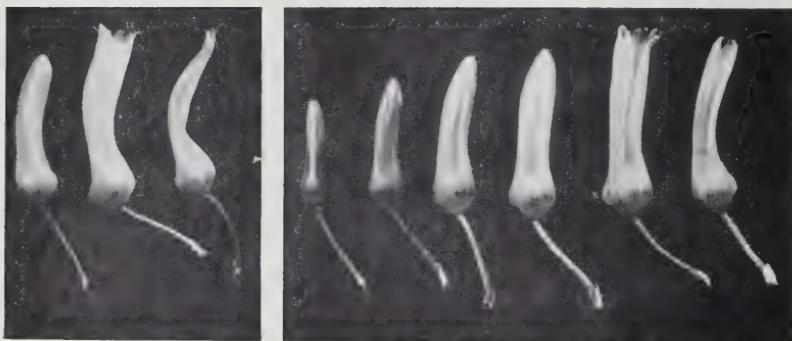
FIG. 4.
Flowers 1 : 1, left: *A. chabaudii*, right: *A. enotata*. Photo: L. C. Leach.

Plants hanging from cliffs, with a simple stem up to 60 cm long, 3 cm diam., sometimes forming clumps from offsets from the base, with a rosette of $\pm$ 12 leaves. *Leaves* 45—60 cm long, 5—6 cm wide towards the base, widely spreading but all becoming strongly falcate and pointing downwards; *upper surface* flat or slightly concave, pale green suffused with pink, especially towards the margins and apex, neither striate nor maculate; *lower surface* convex, somewhat paler in colour than the upper; *margins* very narrowly cartilaginous, sharp

edged, whitish, with small, widely spaced, usually forwardly hooked, pungent teeth, with the interspaces 20—40 mm long (usually $\pm$ 30 mm), mostly straight or $\pm$ following the curve of the falcate leaves. *Inflorescence* a pendulous lax panicle, $\pm$ 85 cm long, branched below the middle, somewhat flexuose between the branches; *peduncle* 32 cm long, purplish brown, almost devoid of bloom, slender, terete, slightly compressed towards the base with sharp lateral angles; the 6 brown, whitish speckled branches of the inflorescence clasped at their base by a pair of unequal whitish bracts; with the racemes horizontally spreading, slightly ascending, or those arising on the lower side of the axis, usually arcuate-ascending. *Racemes* rather laxly flowered, cylindric-acuminate, 14—20 cm long, $\pm$ 7,5 cm diam., with the buds spreading and the open flowers somewhat cernuous. *Bracts* $\pm$ ovate acute, $\pm$ 4 mm long, 3 mm wide, scarious, whitish with 3 blackish brown nerves. *Pedicels* spreading, sometimes apically cernuous, brown and whitish speckled, up to 17 mm long. *Perianth* rather dull red, obscurely purplish striped, with a faint bloom, 25—28 mm long, more or less obtusely obconic at the base, inflated to 8 mm diam. around the ovary, then markedly trigonously indented from there narrowed to about 5,5 mm diam., gradually widening again to $\pm$ 6,5 mm diam. a little below the open mouth; *outer segments* free for 6—8 mm, with 3 red nerves, confluent or almost so towards the apex; *inner segments* wider, shortly lightly keeled, themselves free but dorsally adnate to the outer, with 3 obscure apically confluent nerves, with wide whitish margins becoming orange in their upper third towards the orange-brown apex. *Filaments* lemon-yellow; with the terracotta anthers not or scarcely exserted. *Ovary* 6-grooved, dull yellowish green, faintly orange in the grooves, soon becoming olive-brown, subtruncate at the 2,5 mm diam. base which is broadly fused to the thick fleshy base of the perianth, $\pm$ 5 mm long, tapering to the relatively small ($\pm$ 1 mm diam.) obtusely truncate apex. *Style* lemon; *stigma* whitish, granulate, included. *Seeds* more or less trigonous, brownish black with a few slightly raised paler spots, and thin, narrow, sparingly blackish flecked, whitish wings.

A. enotata would fit into the key in *Reynolds, The Aloes of Tropical Africa and Madagascar* (1966): 162, under Group 10 "Plants pendent, or semi-pendent" "B.—Leaves densely rosulate (not spaced at apex of stems)", but may be "Keyed out" from those included here, as well as from *A. inamara* Leach, by its basally inflated, trigonously indented, red flowers &/or leaves neither spotted nor striate.

TRANSPORT STUDIES ON *GOMPHOCARPUS PHYSOCARPUS:* OBSERVATIONS ON THE FEEDING HABIT OF *APHIS NERII.* B. de F.*

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Abstract

Scanning electron and light microscope studies carried out on the feeding habit of the aphid, *Aphis nerii*, on *Gomphocarpus physocarpus*, underscore the remarkable adaptation of the labium and of the stylet group for puncturing and penetrating plant tissues. Penetration of the stylet pairs is intercellular in the cortex and mainly intracellular in the ray parenchyma. The aphid feeds in sieve elements and, despite the greater distance of traverse, preferentially in those of the internal phloem bundles and should, therefore, be potentially useful in transport studies of dissolved organic substances.

Uittreksel

TRANSLOKASIE-STUDIES OP *GOMPHOCARPUS PHYSOCARPUS*: WAAR-NEMINGS OP DIE VOEDINGSGEWOONTE VAN *APHIS NERII.* B. de F.

Studies wat met behulp van skanderende elektron- en ligmikroskopie op die voedingsgewoontes van die plantluis *Aphis nerii* op *Gomphocarpus physocarpus* onderneem is, bevestig die besondere aanpassing van die stiletgroep en die labium van dié insek ten opsigte van die binnedringing van plantweefsel. Binnedringing van die stiletpare deur die korteks is intersellulêr maar in die straalparenchiem hoofsaaklik intrasellulêr. Dié plantluis voed in die sifvatelemente en by voorkeur in dié van die interne floeëmbondels, ten spyte van die groter afstand van binnedringing as gevolg daarvan. *Aphis nerii* is dus potensieël geskik vir gebruik in translokasiestudies van opgeloste organiese stowwe.

Introduction

In recent years an increasing number of investigators have adopted techniques utilizing aphids and severed aphid mouthparts in their attempts to rationalize some of the many problems and major controversies associated with the translocation of dissolved organic substances in the phloem. Auclair (1963) has reviewed extensively the feeding habit and nutrition of aphids. However, relatively few considerations have been accorded the anatomical and histological aspects of stylet penetration of plant tissues or even, for that matter, the anatomy of the aphid's mouthparts.

Esau, Namba and Rasa (1961) found that about 50 per cent of the deeper punctures left at *Myzus persicae* in sugar beet leaves terminated in the phloem tissue. Zimmerman (1961), and Evert, Eschrich, Medler and Alfieri (1968)

studied the penetration of *Tilia americana* branches by the large aphid *Longistigma caryae*. Evert *et al.* showed that this aphid could feed in phloem sieve elements more than a year old. Hoad, Hillman and Wareing (1971), working with *Tuberolachnus salignus*, found that radioactive indoleacetic acid and its metabolic products were transported in the phloem of *Salix viminalis* L.

In the study reported on here, *Gomphocarpus physocarpus* was selected as experimental material because of the presence of external as well as internal phloem in seedlings and the predominance of internal phloem bundles in adult plants, a feature characteristic of members of the Asclepiadaceae. Also, as far as we are aware, no work has yet appeared which reports specifically on the apparent preference of aphids for internal phloem. Our primary interest is in the study of the transport of plant growth and other substances and it appeared that *Aphis nerii* might be used quite effectively in our work with radioactive materials and particularly on intact plants rather than explants. However, in studies of this nature it is essential to understand the feeding habit of the vector and this paper reports on some of our observations. Other papers following shortly, will report on the physiological work.

Materials and Methods

Colonies of *Aphis nerii* were established on the stems and leaves of nine-week-old seedlings and adult plants of *Gomphocarpus physocarpus*. The aphids were killed *in situ* on leaves and stem segments either by exposing the plant material to an atmosphere saturated with acrolein or by applying acrolein directly with a dropper pipette. Suitable lengths of plant tissue with the dead aphids in their *in situ* feeding positions, were then prepared for microscopic study by fixing in formalin-acetic acid-alcohol and embedding in paraffin wax (Sass, 1958). Sections were cut at 10 μm and stained with safranin and fast green (Johansen, 1947). With this staining combination the aphid's stylet sheaths were stained golden-brown against the usual green and red background and consequently were easily identified. The material used for scanning electron microscopy was simply mounted on specimen stubs by means of a 50 per cent mixture of Samsonite adhesive and silver conducting paint, and coated lightly with evaporated carbon. The specimens were viewed in a Hitachi SSM2 scanning electron microscope. Many aphids were excellently preserved by this procedure although some showed marked distortion. This can probably be attributed to the fact that

Fig. 1.
Ventral view of *A. nerii*. The labium (LA) is in the non-feeding position. Note the labrum (LAB) at the base of the labium covering the stylets (STY). Scale line = 60 μm.
Fig. 2.
Lateral view of the aphid showing labium (LA) and labial groove (LG) in which the stylets lie. Scale line = 70 μm.
Fig. 3.
Distal tip of labium, showing sensory bristles (SB). Scale line = 20 μm.
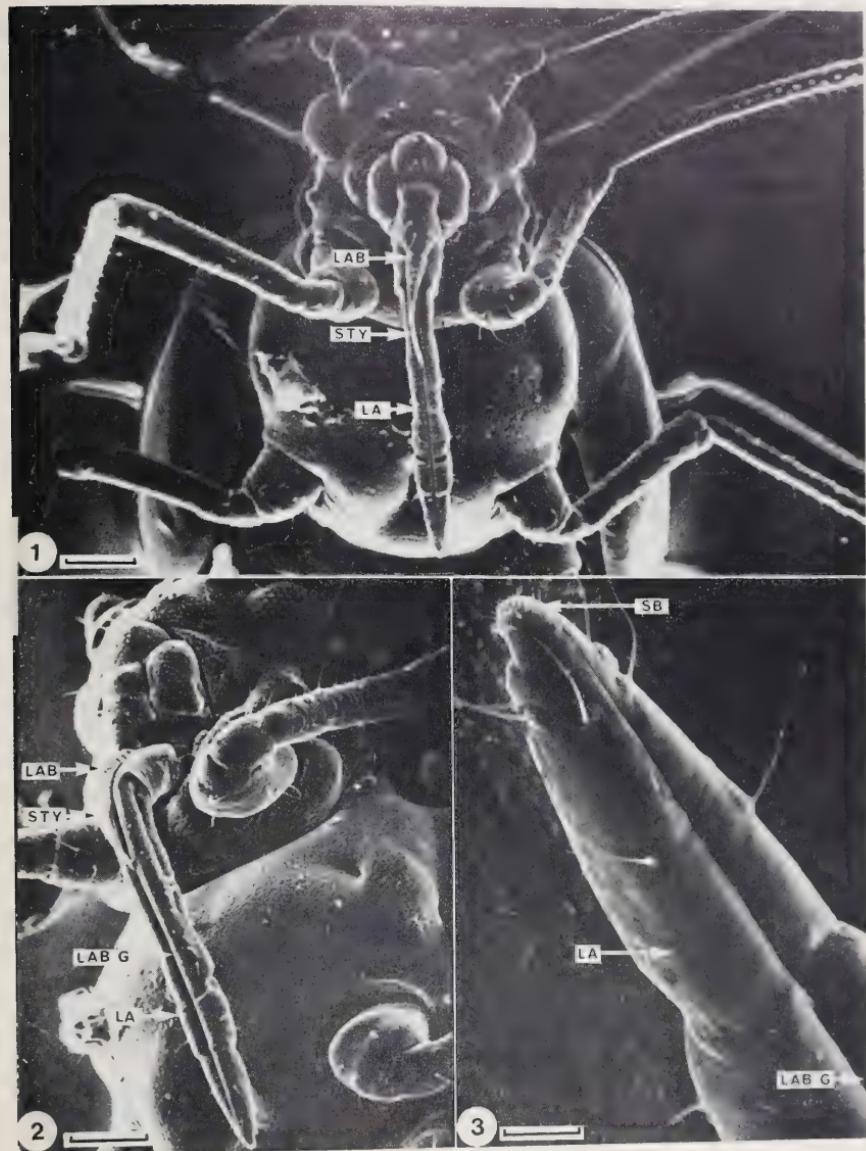
the aphids were at different stages of their life cycles, the adults being better able to withstand the vacuums to which they were subjected by virtue of their thicker, more heavily sclerotised cuticles.

RESULTS AND DISCUSSION

Aphis nerii has been found to feed almost exclusively on *Gomphocarpus physocarpus*. Figures 1–12 emphasize certain morphological features of the aphid and its mouthparts, the latter clearly well-adapted for puncturing and penetrating plant tissues. In Figs. 1 and 2 the labium (LA), which projects downward from the head, is shown in the non-feeding position, that is, with the stylets retracted; note the labial groove (LAB G) in which the two pairs of stylets lie. The proximal end of the labium contains no groove and is covered by the labrum (LAB), a structure which overlies the stylets. The distal end of the labium is surrounded by a ring of sensory bristles (Figs. 3, 4, SB) which are believed to assist the aphid in its selection of a suitable area on the plant epidermis for probing. The sensory bristles project from a muscular clamp or collar (Fig. 4) through which the stylets protrude. The labium is jointed as in most Hemiptera (Figs. 2, 3, 5 and 12) thus rendering it flexible, a function which allows it shortening during stylet penetration and probably also prevents damage to the stylets during probing operations.

The stylet anatomy of *Tuberolachnus salignus* and *Myzus persicae* was investigated by Mittler (1954) and van Hoof (1956), using transmission electron microscopy. Figures 6–9 are scanning electron micrographs of the stylets of *A. nerii* taken at high magnification (5 000 × and more) and reveal some interesting features. The mandibular stylets (Figs. 6, 8, 9, MAN STY) possess hook-like projections on their surfaces about 5,0 μm apart (Fig. 9) on the surface. The maxillary stylets possess a series of lateral tooth-like projections (large white arrows) about 1,0 μm apart and about 5,0—6,5 μm from the apices of the maxillary stylets (Figs. 6 and 9). They are presumed to play a part in the penetration of the stylet group into the plant tissue.

A noticeable feature is the overlapping of the maxillary stylets themselves (Fig. 7). Serial transverse and longitudinal sections of paraffinembedded tissue (Figs. 10–12), provided information on the method of stylet penetration.

FIG. 4.
Distal end of labium showing mandibular stylets (MAN STY) protruding. Scale line = 4,5 μm.
FIG. 5.
Lateral view of *Aphis nerii* showing mouthparts. Scale line = 70 μm.
FIG. 6–9.
Aspects of the stylet tips. Scale lines represent 1,0 μm (Figs. 6–8), and 0,5 μm (Fig. 9). Fig. 6. Lateral view of mandibular (MAN STY) and maxillary stylets (MAX STY). Note tooth-like projections (large white arrow heads). Fig. 7. Ventral view of maxillary stylets. Figs. 8–9. Oblique views of stylet groups. Note the ridges (small arrows) on the mandibular stylets and lateral tooth-like projections (large white arrow heads).
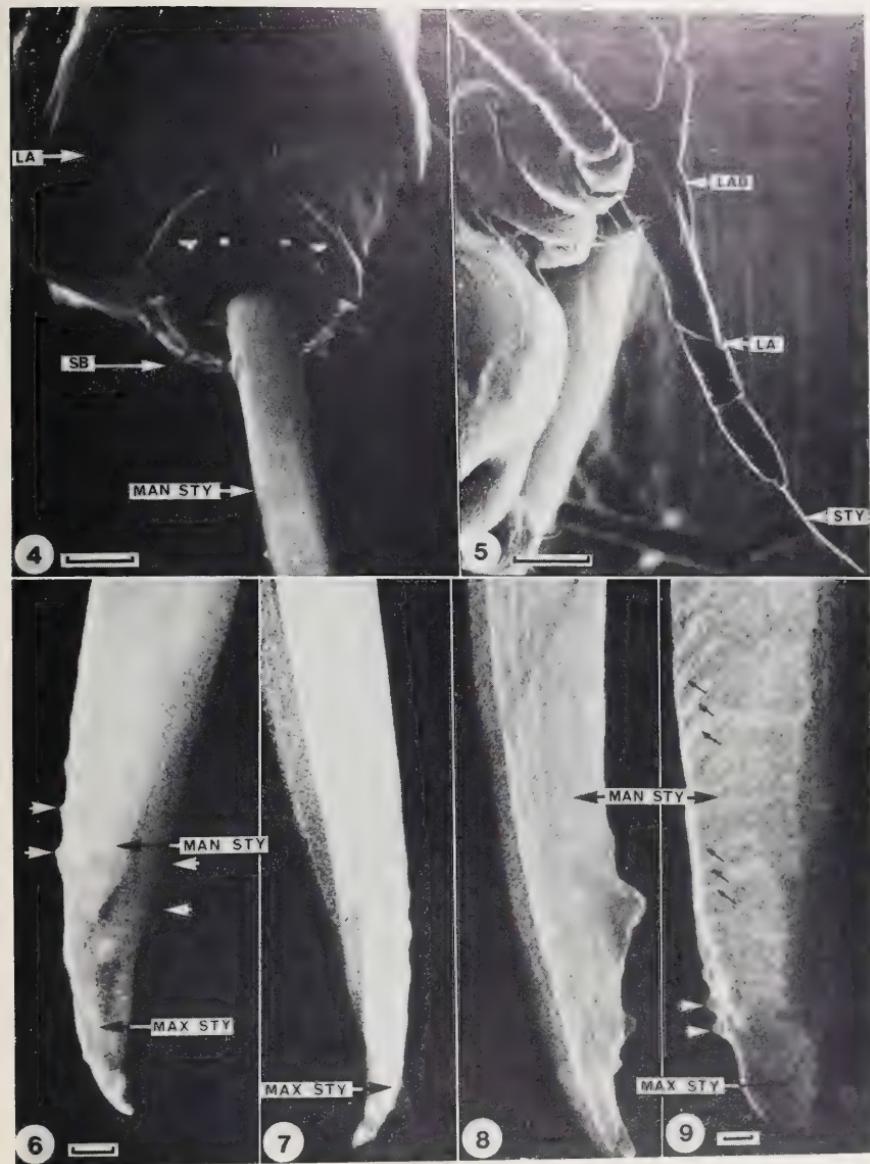
Generally, the stylets appear to be inserted between cell walls (Fig. 13). The stylet track or sheath formed within the plant is nearly twice as wide, from 5,0 to 7,5 μm, than the diameter of the stylets (3,0—3,8 μm). This would seem to result from the action of the saliva which is injected through the maxillaries, and which probably contains enzymes involved in the dissolution of the middle lamella and cell wall substances.

Judged by the intensity of the staining reaction, it appears that less saliva is secreted during intercellular penetration of cortical tissue than is the case during penetration of vascular tissue, particularly through a field of xylem. In the latter instance the saliva sheath often appears puffy in outline (Fig. 13); presumably this is linked to the greater difficulty encountered in penetration and consequently to a more liberal release of the salivary secretions. Where a xylem vessel is punctured, or where the saliva secretion is forced into such a vessel, probably through pits, the gelled saliva obliterates a large portion of the cavity, effectively sealing the track (Fig. 13, lower centre). Upon examination of transverse sections, the distal tips of the stylet sheaths when terminating in sieve elements frequently appeared to be sealed off. Evert *et al.* (1968) interpreted this as being indicative of non-conducting phloem; in other words there is no evidence of surging, an action which would otherwise be associated with functional elements. By no means do all tracks lead to functional phloem. Esau *et al.* (1961) pointed out that the deposition of saliva in sieve elements could interfere with the feeding process by interrupting the transport of sap.

The results of an examination of 10 sections each of young and adult plants containing stylets and stylet sheaths are given in table one on page 202.

In the seedling and adult plant 60 and 80 per cent of the penetrations, respectively, terminated in the internal phloem, despite the greater distance of traverse. The number of functional sieve elements punctured are also greater in the internal phloem.

Fig. 10.

Photomicrograph of longitudinal section through adult *Gomphocarpus physocarpus* stem, showing relationship of *A. nerii* to the stem during feeding. Scale line = 160 μm.

Fig. 11.

Photomicrograph of transverse section through a young 9-week *G. physocarpus* stem and the head of *A. nerii* in feeding position with its stylets protruding through the labium and penetrating the epidermis. Scale line = 160 μm.

Fig. 12.

Photomicrograph of a longitudinal section through labium (LA). Two pairs of stylets—outer mandibular (MAN STY) and inner maxillary (MAX STY)—as well as labial groove (LAB G) are visible. Scale line = 40 μm.

Fig. 13.

Photomicrograph of a transverse section of *G. physocarpus* showing stylets and stylet tracks of *A. nerii*. Details: PAR, parenchyma; PFI, phloem fibre initial; LAT, laticifer; EPSE, external phloem sieve element; EPCC, external phloem companion cell; STY T, stylet track; XP, xylem parenchyma; MXV, metaxylem vessel; IPSE, internal phloem sieve element; IPCC, internal phloem companion cell.
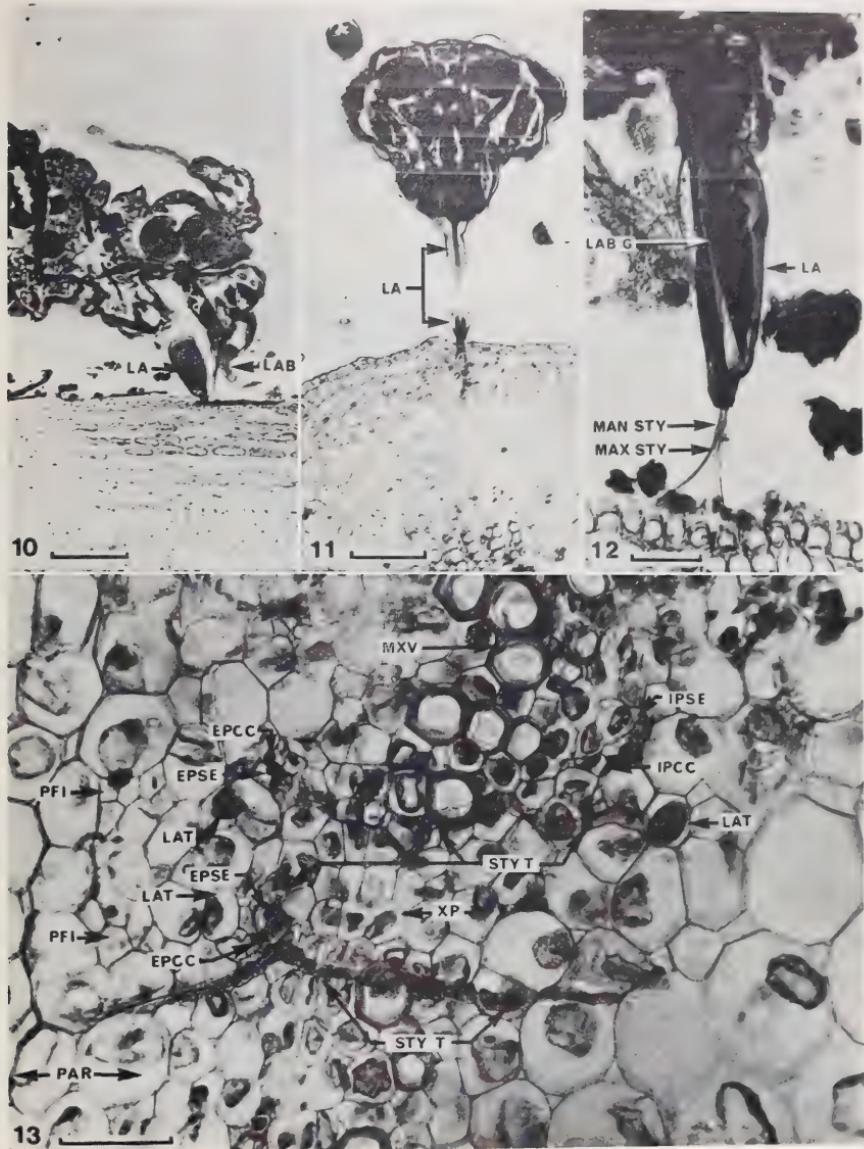
TABLE 1

Average length of stylet sheaths of *Aphis nerii* in young and adult *Gomphocarpus physocarpus* with reference to number of penetrations of functional sieve elements.

	Ave Distance in μm from Epidermis to:		
	External Phloem	Internal Phloem	Centre of Stem
9-Week-Seedling	320	439	931
No. of penetrations	4	6	
No. of functional sieve elements	4	5	
No. of branched stylet sheaths .	4	2	
Adult Plant	341	594	1333
No. of penetrations	2	8	
No. of functional sieve elements	1	7	
No. of branched stylet sheaths .	1	1	

The tracks or sheaths frequently appear forked in the vicinity of the vascular tissue (Fig. 13). Evert *et al.* (1968) also reported that in *Tilia americana* branching of the stylet tracks usually occurred in the region of living sieve elements. In young *G. physocarpus* seedlings branching of the stylet tracks may be influenced by the very narrow diameter of some of the sieve elements, some of which were of the order of only 10 μm. In adult *G. physocarpus* stylet tracks were found to follow a fairly straight course through the cortex and ray parenchyma of the xylem, ending usually in a bundle of internal phloem. Mittler (1957) suggested that the branching phenomenon in phloem may reflect the aphid's response to a local exhaustion of sieve-tube sap or even to a lack of sufficient pressure for the aphid to continue its feeding at a normal rate.

CONCLUSION

Observations on the mode of penetration of the stylet pairs and the termination of the stylet sheaths leave no doubt that *Aphis nerii* feeds in the sieve elements, particularly in those of the internal phloem bundles. This aphid, although small, is therefore potentially useful in transport studies of dissolved organic substances in *Gomphocarpus physocarpus*. Pending further intensive investigation we are led to surmise, at this stage, that the predominace of stylet sheaths terminating in the internal phloem is an indication of its sieve elements being the more functional in the translocation of photosynthates. Penetration of the stylets is mostly intercellular in the cortex and mainly intracellular in the ray parenchyma. Scanning electron microscopy of the labium and stylet pairs confirm their remarkable adaptation for puncturing and penetrating plant tissues.

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Book Reviews

THE RUST FUNGI OF CEREALS, GRASSES AND BAMBOOS by G. B. Cummins, with pp. xv + 570. Berlin, Heidelberg, New York: Springer-Verlag, 1971.

Professor Cummins has tried to fill a gap by compiling an illustrative manual of worldwide rusts of cereals, grasses and bamboos. Other monographs, e.g. Arthur (Manual of the rusts in U.S. and Canada, 1954), Gäumann (Die Rostpilze Mitteleuropas, 1959) and Wilson and Henderson (British Rust Fungi, 1966), have been confined to specific areas. Thus with the publication of the present book under review, one is waiting for other manuals of related diseases of a global nature.

The manual provides two useful keys. One is a key to species by genera of hosts. This will be more frequently used than the second one which is a series of keys to species of *Dasyturella*, *Phakopsora*, *Physopella*, *Stereostratum*, *Puccinia* and *Uromyces*. Here, the author has tried to produce a system by which the rust fungi are recognized solely on the basis of their morphology, although this (as the author puts it) is a "Utopian goal" and is a very brave attempt. There are descriptions of each fungus species. Most are illustrated with excellent drawings but they all lack the basic information, e.g. identification and scale. However, the author does indicate the magnification of these drawings in the explanations section.

Doidge (The South African Fungi and Lichens, Bothalia, V, 1945) lists thirty-six *Puccinia* species, nine *Uromyces* and three *Uredo* species found on grasses in South Africa, but there appears to be a real need for a new revision of these rusts. All are described in Cummins's Manual, and this would be used as the major reference for such an investigation.

Clearly, this book will be of tremendous use to the specialist in "Uredinology", but one wonders how useful it will be to the applied plant pathologist, and the agricultural adviser. Cereal rusts have reached such specialization that one is more interested in their physiological races and the distribution of these races throughout the world. Admittedly, this would have been an extremely bold task, but if only an attempt had been made, this could have been of more use and a general reference book for the plant pathologist.

<div align="right">D. T. MITCHELL</div>

THE DIVERSITY OF GREEN PLANTS by Peter Bell and Christopher Woodcock, with pp. ix + 374 and 276 figures. London: Arnold, 1971. £5; paperback £2·50.

The purpose of this book is stated by the authors to be to present a "concise account of the structure and reproduction of the varied groups of autotrophic plants, both living and extinct, proceeding from the simple to the complex". They suggest in their preface that an understanding of the results of research on problems of growth and development is facilitated by an awareness of the inter-relationships of the organism used. They have produced a more or less conventional comparative study of the eutrophic plants, with very occasional reference to physiological aspects.

The text is accurate and readable, based primarily on a description of a series of types. The flowering plants are treated differently, referring to examples, but not employing types or taxonomic subdivisions of this group.

A glossary defines some 450 terms, not defined in the text. There is a list of references, but no sources for extra reading. The index is comprehensive, but would have been more useful had some of the entries been further subdivided. One finds, for example, a bewildering array of forty references under the entry "sporangium"! The illustrations are quite adequate both in quality and in relevance.

This edition does not differ greatly from the first. Several illustrations have been redrawn and there are a few additional ones. One of the more obvious alterations to the text has been the recognition of the Metzgeriales as being distinct from the Jungermanniales. However the only change made to incorporate this order is to replace the term "Jungermanniales" with the phrase "Jungermanniales and Metzgeriales", with no explanation of any differences between these orders.

The printing of text, half-tone and line illustrations is clear, but the lettering of the spine is not as legible as it might be.

"The diversity of green plants" is probably too detailed for first year university students and insufficient for use as the principal source for senior students. Nevertheless, several

South African universities have prescribed the first edition for use by both first year and more senior students, and it would certainly provide a reliable and readable reference work as a background to more specialised studies.

J. P. Jessop

Trees Structure and Function by Martin H. Zimmerman and Claud M. Brown with pp. xiv + 336 and 111 illus. Berlin, Heidelberg, New York: Springer-Verlag, 1971. $19,80.

This is a modern account of major questions of the physiological anatomy of trees. The authors presuppose basic knowledge of plant anatomy and physiology and proceed to explain the relations between growth, structure and function in trees. The approach is that which has been applied to explain the structure and life of forest trees by Büsgen and Münch.[1]

This book should be of considerable value as a reference work for intensive study by senior botany students and post-graduate research workers in botany, forestry and related fields. The basic botanical training of undergraduates in the applied sciences of forestry, agriculture and horticulture is generally somewhat limited and they may find the terminology unfamiliar and the numerous references confusing.

There are seven chapters, i.e. on primary growth; secondary growth; growth and form; transport in the xylem; transport in the phloem; the steady state thermodynamics of translocation in plants, and storage, mobilization and circulation of assimilates. The subject index is adequate and the author index of six pages, is comprehensive. The chapters are followed by extensive lists of the literature cited, and these cover a total of 25 closely printed pages. This bibliography alone makes the book very valuable for botanists, who investigate the physiological anatomy of plants, and particularly, forest scientists engaged in silvicultural and wood technological research.

The foundations of silviculture (silvics) have, in the past, been predominantly ecological. It has been attempted to explain *what* the relations of trees to their environment (autecology) and their inter-relations in forest communities (synecology) are. Research into silvicultural practice has aimed at determining *what* the effects of treatments applied in experiments are. Fundamental knowledge of the relations between the structure and function of cell-tissues, organs and whole trees, as set forth in this book, is needed, however, to understand *why* trees and forests stands react in particular ways to their environments and in associations, and also *why* silvicultural treatments cause stands to respond in particular ways.

The information in the chapters by Brown on primary growth, secondary growth and growth and form, is needed by the silvicultural researcher and, as the object of commercial forestry is to produce timber of desirable quality, the knowledge presented in these chapters is also needed if silviculturists and wood technologists are to co-operate successfully to this end. Thus, to select but one example, the section on reaction wood is of particular interest in relation to the problem of the warping of South African pine timber, caused by the formation of such wood.

Growth and form of trees is described with reference to the aerial parts and roots are considered only rather briefly in sections of the first and second chapters. Fuller information on roots as presented, for example, by Köstler, Brückner and Bibelriether,[2] could profitably have been included.

The problems of transport in the xylem and the phloem, dealt with in chapters four and five, are obviously significant in connection with the study of the water relations of trees, the hydrological effects of forests, the intake of solutes from the soil and the distribution of photosynthetic products through tree systems. This applies also to the question of storage, mobilization and circulation of assimilates discussed in chapter seven.

Basic research into trees, structure and function has been either physiological or physical. This book has presented, collated and discussed physiological information mainly. The mathematical-physical chapter by Tyree does not fit quite logically into the pattern of the book. Most students may want to skip this chapter or perhaps return to it after they have more fully studied the physical reactions determining the input and output of energy, water, carbon, oxygen, nitrogen and minerals to and from tree systems.

The complete subject matter of the physiological anatomy of trees is not dealt with. The three main fields covered are: growth, by Brown; transport and storage, by Zimmerman; and thermodynamics of translocation, by Tyree. The chapters by the individual authors are excellent contributions on selected subjects rather than integrated parts of a comprehensive treatment.

The overall appearance, quality and accuracy of the text, quality, accuracy and relevancy of illustrative matter and the balance between illustrations and text are all of the highest standard.

1. Büsgen, M. & E. Münch, 1927. "Waldbäume" *Verlag von Gustav Fischer, Jena.*
2. Köstler, J. N., E. Brückner & H. Biebelriether, 1968. "Die Wurzeln der Waldbäume" *Verlag Paul Parey, Hamburg & Berlin.*

C. L. Wicht

Pollen: Development and Physiology, ed. by J. Heslop-Harrison, with pp. xi + 338. London: Butterworths, 1971.

The contents of this book are clearly summarised in the foreword by Dr. Erdtman who states: "The reviews and abstracts published in this book are an up-to-date synopsis of new acquisitions and ideas within the fertile field of pollen physiology, concerning the living pollen grains, their growth and essential biological functions."

In the preface, the editor Professor Heslop-Harrison explains that the contents of the book were derived from extended versions of papers and abstracts of research reports given at three meetings held in the State of Washington, U.S.A., during August, 1969. Two meetings in Pullman were held under the auspices of the American Association for the Advancement of Science and the one in Seattle formed part of the work of the XIth International Botanical Congress.

The contents of the book, defined by the editor as a text book is divided into five sections. Section one deals with "The nucleus and cytoplasm in microsporogenesis" (two reviews and two abstracts). Section 2 is entitled "Pollen Development and the Pollen grain wall" (three reviews and seven abstracts). Section 3 on "Pollen and Pollen Tube metabolism" contains four reviews and nine abstracts while Section 4 is called "Pistil-Pollen interactions" consisting of one review and four abstracts. The final section is headed "Incompatibility" and comprises one review and three abstracts.

It is apparent from the very brief description of the book given above that all the important developmental and physiological aspects of pollen are dealt with. Adequate lists of references are given with each review and research abstract.

This is an admirable book for senior students and research workers in this specialised field and no university library should be without it.

E. S. Twyman

Flora of New Zealand Vol. II by L. B. Moore and E. Edgar with pp. xl + 354, 4 Maps, 43 text figs. Wellington: A. R. Shearer, Government Printer, 1970. $4,50 (N.Z.).

When compared with other Southern Hemisphere countries, New Zealand has fared very well as regards the writing of a standard flora. While most of these countries count themselves fortunate to have even one published flora, New Zealand has had 3; starting with Hooker's *Handbook of the New Zealand Flora* (1867), followed by Cheeseman's *Manual of the New Zealand Flora* (1906) and now the *Flora of New Zealand*, of which volume II is reviewed here. This progress is undoubtedly due to the fact that the number of taxa to be dealt with is vastly smaller than for most other countries. The number of species of vascular plants making up the New Zealand flora is about 1 460, that is, somewhat more than half the number recorded for the Cape Peninsula.

Despite this numerical advantage, 9 years have passed since the appearance of volume I, which dealt with vascular cryptogams and dicotyledons. With the exception of the Graminae, volume II enumerates the Monocotyledons. Presumably the Graminae will receive attention at a later date. The major cause of the delay in the appearance of volume II is apparently not due to the ponderous progress of orthodox taxonomy which bogs down so many floras, but is largely due to the inclusion of some biosystematic data. In the preface we learn that the authors were able "to grow a large proportion of the species and obtain some experimental evidence about hybridization". Moreover, chromosome numbers are listed for half the taxa enumerated in volumes I and II. There can be few floras in the world for which such claims can be made.

Another interesting feature of this work is that the families have been arranged according to Hutchinson's classification. Keys to the families, genera and species are provided and are clearly set out with well contrasting couplets. For many genera there are excellent line drawings of the diagnostic parts, those depicting the columns of *Thelymitra* (Orchidaceae) being particularly notable. Predictably, a family like the Orchidaceae tends to get extra attention, but in this publication even the Cyperaceae are well catered for with fine line drawings.

Throughout the text, abundant references to papers of relevance are provided in the critical discussions following the species descriptions. In addition, an "Annals of Taxonomic Research" on New Zealand vascular plants has been compiled, listing papers published between 1959 and 1968, together with papers dating from 1780 that were not included in a similar list in volume I. A subject index to the "Annals", arranged alphabetically under families, greatly enhances the value of this reference source. A glossary of botanical terms and corrigenda to volume I complete the text. Maps on the end papers depict the New Zealand Botanical Region, the Southern Islands in relation to the larger land masses and details of both South and North Islands of New Zealand.

Much thought has evidently gone into the production of this excellent book in which it is hard to find deficiencies or omissions. One must congratulate Dr. Edgar and Dr. Moore for producing so compact and handy a book containing so much information. It will undoubtedly be an invaluable reference work for all taxonomists in the Southern Hemisphere. This book is very moderately priced.

J. P. ROURKE

INSTRUCTIONS TO CONTRIBUTORS
TO THE
JOURNAL OF SOUTH AFRICAN BOTANY

This Journal provides a medium for the publication of the results of botanical research primarily on the flora of Southern Africa, whether systematic, morphological, ecological or otherwise and whether carried out in South Africa or elsewhere. Papers on botanical subjects of special interest and application in South Africa may be included.

Contributions must be original and should not be translations of previously published papers.

Papers must be submitted in final, corrected form. They are accepted for publication on the recommendation of the Editorial Committee.

Authors may be charged expenses for corrections if alterations are excessive.

COPY

Papers should be type-written, double spaced throughout on one side of the paper and with margins of at least 3 cm (1 inch). Footnotes and elaborate tables should be avoided. Latin binomials should be underlined once to indicate italics. All other marking of copy should be left to the Editor. The original, plus at least one carbon copy, must be submitted.

GENERAL LAY-OUT

Each paper should be headed with a concise informative **title** in capitals with the author's name below. This should be followed by the name of the institution, where the work was carried out, underlined and placed within brackets.

A concisely written **abstract** in English and Afrikaans, of not more than 200 words, should precede the text.

The subject matter should be divided into sections under short appropriate **headings** such as: INTRODUCTION, MATERIAL AND METHODS, RESULTS, DISCUSSION, CONCLUSION, ACKNOWLEDGMENTS, etc.

Tables and **illustrations** should be on separate sheets. **Figures** and **graphs** should be in Indian ink on white card or Bristol board. Lettering for figures can be inserted by the printers in which case authors should indicate the desired lettering on the original figure lightly in pencil. The maximum dimensions available for figures are 18 cm × 12 cm ($7'' \times 4\frac{1}{2}''$). Line drawings for blocks should be at least twice the size they will be when reduced for publication. All figures should be supplied with a scale. The most suitable method of indicating magnification is a scale line (in metric units) incorporated in the figure. Photographs for half-tone reproductions should be on glossy paper, clearly marked on the reverse side (in pencil) to indicate the top. Line drawings and half-tone illustrations are termed figures and should be numbered consecutively. Captions for figures should be typed on a separate sheet of paper.

TAXONOMIC PAPERS

Authors must adhere to the International Rules of Botanical Nomenclature. **Abbreviations** and **herbaria** must be cited in accordance with the most recent edition of Index Herbariorum, Pt 1 (The Herbaria of the World, 5th ed., 1964). When **new species** are described, the exact location of type material must be indicated. When proposing **new combinations** the full citation of the basionym is required. **Indented keys** with numbered couplets are preferred when dealing with a small number of taxa. **Bracket keys** should be used when dealing with a large number of taxa. When citing **synonyms** they should be arranged chronologically into groups of nomenclatural synonyms and these should be

arranged chronologically by basionyms. Whenever possible, the types of the basionyms should be cited, e.g. :

Bequaertiodendron magalismontanum (Sond.) Heine & J. H. Hemsley in Kew Bull. **1960**: 307 (1960).
Chrysophyllum magalismontanum Sond. in Linnaea **23**: 72 (1850). Type: Magaliesberg, *Zeyher,* 1849 (S, holo; BOL!, SAM !).
Zeyherella magalismontana (Sond.) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).
Pouteria magalismontana (Sond.) A. Meeuse in Bothalia **7**: 335 (1960).
Chrysophyllum argyrophyllum Hiern, Cat. Afr. Pl. Welw. **3**: 641 (1898). Syntypes: Angola, *Welwitsch* 4827, 4828, 4829 (BM !).
Boivinella argyrophylla (Hiern) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).
Chrysophyllum wilmsii Engl., Mon. Sapot. Afr.: 47 t. 16 (1904). Type: Transvaal *Wilms* 1812 (B†, holo.; K !).
Boivinella wilmsii (Engl.) Aubrév. & Pellegr. in Bull. Soc. bot. Fr. **105**: 37 (1958).

CITATION OF SPECIMENS

In the interests of uniformity contributors are requested to follow the recommendations of the Botanical Research Institute, Pretoria (Technical note: Gen. 4, Oct., 1967) by citing specimens according to the one degree grid system. Distribution data are given separately for each province and are arranged in the following sequences: South West Africa, Botswana, Transvaal, Orange Free State, Swaziland, Natal, Lesotho, Cape. Within each province degree squares are listed in numerical sequence, i.e., from west to east and from north to south. Whenever possible locality records should be given to within a quarter degree square. The collectors' names and numbers are underlined (printed in italics) to avoid confusion with the numbers of the degree squares, e.g.: NATAL-2829 (Harrismith): Cathedral Peak Forest Station (-CC), *Killick* 5127 (PRE); . . . CAPE-3418 (Simonstown): Hottentots Holland mountains, Somerset Sneeukop (-BB), Nov., *Stokoe s.n.* sub. SAM *56390* (SAM).

REFERENCES

These should be given in the text as follows: Jones (1968) or (Jones, 1968) or, where reference to a specific page is required, Jones (1968:57) or (Jones,1968:57). **Literature cited** should be arranged alphabetically by surnames, chronologically within each name, with suffixes a, b, etc., to the year for more than one paper by the same author in that year. Titles of **periodicals** must be abbreviated according to the *World List of Scientific Periodicals,* 4th ed., London: Butterworth or when unable to trace the title in this list (as will be the case in taxonomic papers where abbreviations of 18th and 19th century periodicals art required) the abbreviations given in *Botanico-Periodicum-Huntianum,* Pittsburgh: Hune Botanical Library, 1968, should be followed. Periodical titles should be underlined once (for italics). If an author is unable to determine the correct abbreviation of a journal title he is advised to type it out in full and leave its abbreviation to the Editor. Titles of **books** should be underlined and given in full, together with the place of publication, name of the publisher and an indication of the edition if other than the first; e.g.:

Davis, P. H. and Heywood, V. H., 1963. *Principles of Angiosperm Taxonomy.* Edinburgh and London: Oliver and Boyd.
Riley, H. P., 1960. Chromosome numbers in the genus *Haworthia. Jl S. Afr. Bot.* **26**: 139–148.

SHORT COMMUNICATION

THE EFFECTS OF APPLIED HORMONES ON GERMINATION OF EXCISED EMBRYOS OF *PROTEA COMPACTA* R.Br. IN VITRO*

J. van Staden, N. A. C. Brown and J. Button

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ABSTRACT

It is suggested that the inhibitor(s) present in the embryos of *Protea compacta* block both chlorophyll synthesis and germination. The latter process appears to be more effectively inhibited than the former. Kinetin and gibberellic acid can partly overcome the inhibition of both these phenomena while indoleacetic acid can only overcome the inhibition of chlorophyll synthesis.

UITTREKSEL

DIE INVLOED VAN TOEGEDIENDE HORMONE OP DIE ONTKIENING VAN *PROTEA COMPACTA* R.Br. IN VITRO.
Daar word voorgestel dat die inhibeerder(s) in *Protea compacta* embrios beide bladgroensintese en ontkieming inhibeer. Laasgenoemde word skynbaar meer effektief gestrem as eersgenoemde. Kinetien en gibberelliensuur kan die inhibisie van beide prosesse gedeeltelik oorkom terwyl indoolasynsuur slegs effektief is in die geval van chlorofilsintese.

It has previously been reported (Atkinson, 1961; Brown and Van Staden, 1971) that excised embryos of certain proteaceous species did not resume normal growth when placed under conditions suitable for germination. When excised, the embryos were very susceptible to fungal infection. Treatment with a fungicide, however, did not improve germination. The fact that removal of the testa did not increase germination suggested that dormancy was not coat imposed, but rather due to innate embryo dormancy. This is possibly due to inhibitors which have been found in the embryo extracts of a number of species (Van Staden and Brown, 1972) or to a lack of promotors.

Wareing and Saunders (1971) reported that the embryo dormancy in a wide variety of seeds can be overcome by the application of gibberellins and cytokinins. In this study gibberellic acid (GA_3), indoleacetic acid (IAA) and kinetin were applied to excised embryos of *P. compacta* under sterile conditions in an attempt to overcome dormancy. Excised embryos were used as it was considered that the hard seed coat, enclosing the mature embryos would severely restrict the movement of applied growth regulators.

Seeds were sterilized by immersion in 3,5% sodium hypochlorite solution for 15 min. followed by 5 min. in 1% Cetavlon in 95% ethanol. They were then

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rinsed in sterile water, the seed coats removed, and the embryos transferred to the culture tubes. Each treatment was replicated 12 times.

The embryos (cotyledons plus radicles) were cultured on the medium of Murashige and Skoog (1962) to which was added 2% sucrose and 1% agar. Each of the following concentrations (mg/l) of growth regulator was tested separately: Kinetin and IAA (0,0001; 0,01; 0,1; 1,0; 10,0) and GA$_3$ (0,01; 0,1; 1,0; 10,0; 100,0). Cultures were kept at 25° with 12 hr photoperiod (light intensity 3,0 × 10² Im/m²). Elongation of the radicle was regarded as positive evidence of germination.

The first visible change to the naturally etiolated embryos was the appearance of chlorophyll in the cotyledons. This greening of the cotyledons always preceded radicle growth (germination) where the latter occurred. In most cases, however, greening of the cotyledons was not followed by radicle growth (Table 1). This suggests that the block to chlorophyll synthesis can be overcome more easily than the block to radicle growth. Alternatively it is possible that two different inhibitors are functional in the embryos, the effect of one being more easily overcome than that of the other. It is quite possible that this inhibition of chlorophyll synthesis in excised *P. compacta* embryos is a result of the inhibition of protein synthesis as Bogorad (1966) has shown that continuous synthesis of proteins is necessary for the maturation of proplastids to chloroplasts in etiolated leaves.

The application of IAA did not bring about germination of excised embryos. It would appear, therefore, that IAA is unable to overcome the inhibition of radicle growth. The number of embryos in which chlorophyll appeared, however, increased five-fold by the application of 0,1 mg/l IAA. With an increase in GA$_3$ in the culture medium from 0,01—1,0 mg/l the percentage of embryos in which chlorophyll synthesis occurred, increased from 25—57. Germination, however, only occurred when 1,0 mg/l GA$_3$ was applied. This concentration of GA$_3$ resulted in 43% of the embryos germinating compared to the 21% of intact seeds in petri dishes. Higher concentrations of GA$_3$ (10 and 100 mg/l) did not bring about any growth. Although not as effective as GA$_3$, a concentration of 0,01 mg/l kinetin resulted in increased germination of the excised embryos. The apparent inability of 0,1 mg/l of kinetin to enhance greening or germination cannot be explained. At a concentration of 1,0 mg/l kinetin considerable elongation of the radicle occurred, but no new roots were formed. This was probably due to the fact that the concentration of kinetin in the medium was too high for root formation.

Van Staden and Brown (1972) found a number of germination inhibitors in extracts of dormant *P. compacta* seed. The major inhibitor appeared to be coumarin-like in its properties. Whether or not these inhibitors play a role in the dormancy of the seed under natural conditions was not shown.

In situations where coumarin has been known to inhibit germination, the effect cannot be reversed by IAA or GA$_3$ (Khan and Tolbert, 1966). Knypl (1967) reported that GA$_3$ was only effective in overcoming the effect of coumarin in kale seeds after prolonged periods of soaking. However, he found that kinetin could markedly reduce its inhibitory effect. There thus may be an interaction between coumarin, GA$_3$ and kinetin similar to the one existing between abscisic acid (ABA), GA$_3$ and kinetin in situations where ABA is responsible for seed dormancy.

The present data do not contribute to our knowledge of the nature of the inhibitor in dormant embryos of *P. compacta* beyond suggesting that there may be an interplay between it, GA$_3$ and/or kinetin.

Webb and Dumbroff (1969), Corcoran (1970) and Thompson (1970) have shown that embryo dormancy of a number of species can be overcome by applying gibberellins and cytokinins to intact seed. The possibility of breaking the dormancy of proteaceous seed in a similar way is at present being investigated.

TABLE 1.
Effects of kinetin, IAA, and GA$_3$ on the development of *Protea compacta* embryos in culture

Hormone	Treatment Concentration (mg/l)	% Cotyledons Green	% Germination
Control	—	10	0
Kinetin	0,001	50	0
	0,01	50	33
	0,1	0	0
	1,0	57	14
	10,0	0	0
IAA	0,001	0	0
	0,01	25	0
	0,1	50	0
	1,0	0	0
	10,0	0	0
GA$_3$	0,01	25	0
	0,1	43	0
	1,0	57	43
	10,0	0	0
	100,0	0	0

Intact seed in petri dishes: 21% germination

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AN ANNOTATED CHECK-LIST TO THE VASCULAR FLORA OF THE UBISANA VALLEY, MTUNZINI, ZULULAND

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Abstract

A check-list with notes on the growth form, habitat, flowering period and flower colour of the plant species of the Ubisana Valley is presented.

Uittreksel

'N GEANNOTEERDE KONTROLELYS VAN DIE VAATPLANTE VAN DIE UBISANA-VALLEI, MTUNZINI, ZULULAND.

'n Kontrolelys met notas oor groeivorm, habitat, blomtyd en blomkleur van die plantsoorte van die Ubisana-vallei word aangebied.

Introduction

The Ubisana Valley is situated approximately 4 km north-east of the well-known and important Ngoye Forest Reserve on the slope of the Ngoye Mountain in the Mtunzini District of Zululand. The valley extends over approximately 1,3 km², and varies in altitude from 48 to 183 m above sea-level.

The general climate is sub-tropical. Precipitation, temperature and humidity are high, especially during summer.

The vegetation varies from xerophytic to mesophytic and hydrophytic. Tree, grass and sedge communities form the major components of the vegetation (Venter, 1969).

The flora of the Ubisana Valley forms part of the Zululand Coast Flats Flora, but a number of species come from the neighbouring thornveld.

This check-list forms part of an ecological survey carried out in the Ubisana Valley (Venter, 1969).

Floristic Data

The vascular flora of the Ubisana Valley is represented by 106 families, 423 genera and 660 species. Twenty five species belong to the Pteridophyta, one to the Gymnospermae, 191 to the Monocotyledoneae and 443 to the Dicotyledoneae. Collecting was carried out intensively over a period of four years and as the Ubisana Valley only covers some 1,3 km² very few species could have escaped detection.

The most important families and genera comprising one percent or more of the total number of species present, are listed in Tables 1 and 2 respectively.

An attempt was made to analyse the flower colour representation in the Ubisana Valley Flora (Table 3). Data was available for 446 species only as the grasses, sedges and ferns were naturally excluded, while the flower colour for a number of species is still unknown to the author.

Yellow and white are the most common colours and are exhibited respectively by 30,4 and 29,7 percent of the species (Table 3). These two colours are followed by red, mauve and pink that are far less common.

Yellow is especially common in the Leguminosae and Compositae, but is general for a large number of families.

White is also common in the Compositae, but more so in the Rubiaceae. It is of interest to note that such a large number of tree species produce white flowers, although yellow-green is also often found.

The flowering periods of the different species are incorporated in the check-list, but these could be improved upon.

TABLE 1
The most important families of the Ubisana Valley Flora.

Families	Genera Number	Species	
		Number	% of total
1. Compositae	34	75	11,4
2. Gramineae	42	70	10,6
3. Leguminosae	27	65	9,9
4. Cyperaceae	13	36	5,5
5. Liliaceae	15	30	4,6
6. Rubiaceae	20	28	4,3
7. Asclepiadaceae	14	19	2,9
8. Scrophulariaceae	14	16	2,4
9. Euphorbiaceae	12	16	2,4
10. Acanthaceae	10	13	2,0
11. Amaryllidaceae	6	12	1,8
12. Labiatae	10	11	1,7
13. Orchidaceae	8	11	1,7
14. Anacardiaceae	5	9	1,4
15. Iridaceae	7	8	1,2
16. Commelinaceae	5	8	1,2
17. Moraceae	1	8	1,2
18. Malvaceae	4	7	1,1
19. Ebenaceae	2	7	1,1

CHECK-LIST

Genera of the Pteridophyta have been arranged according to Schelpe (1969). The genera of the Spermatophyta have been arranged after Dalla Torre et Harms (Phillips, 1951). Species have been listed alphabetically.

TABLE 2
The most important genera of the Ubisana Valley Flora

Genera	Species	
	Number	% of total
1. Helichrysum	14	2,1
2. Cyperus	11	1,7
3. Senecio	11	1,7
4. Crotalaria.	9	1,4
5. Ficus	8	1,2
6. Eragrostis	7	1,1

TABLE 3
Flower-colour representation in the Ubisana Valley Flora

Colour	Species	
	Number	Percentage
Yellow	136	30,4
White	133	29,7
Red	28	6,2
Mauve	27	6,0
Pink	23	5,5
Purple	20	4,5
Blue	19	4,3
Yellow-green.	17	3,8
Green	15	3,4
White-green	9	2,0
Orange	8	1,8
Maroon	6	1,3
Yellow-brown	4	0,9
Grey	1	0,2
TOTAL	446	100,0

REFERENCES

PTERIDOPHYTA

Lycopodiaceae

Lycopodium cernuum L. Common in swampy places.

Psilotaceae

Psilotum nudum (L.) Griseb. Rare. Rock crevices in stream bank forest.

Selaginellaceae

Selaginella dregei (Presl) Hieron. Pioneer on rock.
S. mittenii Bak. Uncommon. Damp soil in deep shade.

Marattiaceae

Marattia fraxinea Sm. ex Gmel. var. *salicifolia* (Schrad.) C. Chr. Rock crevices, in shade.

Osmundaceae

Osmunda regalis L. Common on swampy soil.

Cyatheaceae

Cyathea dregei Kunze. Stream bank forest.

Dennstaedtiaceae

Pteridium cquilinum (L.) Kuhn. Common in grassland around forest margins.

Adiantaceae

Pityrogramma calomelanos (Sw.) Link var. *aureoflava* (Hook.) Weath. ex Bayley. Moist drainage ditch.
Adiantum capillus-veneris L. Moist, shady localities.
Pteris catoptera Kunze. Shady rock crevices.
Cheilanthes multifida (Sw.) More xerophytic rock crevices.
Pellaea calomelanos (Sw.) Link. Shallow soil on rock.
P. hastata (L.f.) Link. Shallow soil on rock.
P. quadripinnata (Forsk.) Prantl. Shallow soil on rock.
P. viridis (Forsk.) Prantl. Forest floor and rocky grassland.

Lindsaeaceae

Lindsaea ensifolia (Sw.) J. Sm. Stream bank forest.

Polypodiaceae

Polypodium polypodioides (L.) Hitch. subsp. *ecklonii* (Kunze) Schelpe. Stream bank forest.
Phymatodes scolopendria (Burm.) Ching. Forest floor.

Davalliaceae

Davallia chaerophylloides (Poir.) Steud. Moist forest floor.
Nephrolepis biserrata (Sw.) Schott. Swamp forest floor. Locally dominant.

Thelypteridaceae

Thelypteris bergiana (Schlechtd.) Ching. Rock crevices, in shade.
T. dentata (Forsk.) E. St. John. Stream bank forest.

Blechnaceae

Blechnum punctulatum Sw. Moist rock crevices.
Stenochlaena tenuifolia (Desv.) Moore. Dominant on floor of swamp forest.

GYMNOSPERMAE

Stangeriaceae

Stangeria eriopus (Kunze) Nash. Grassland, uncommon.

ANGIOSPERMAE

MONOCOTYLEDONEAE

Typhaceae
Typha latifolia L. subsp. *capensis* Rohrb. Stagnant water, dominant in places. Fl. Nov. Jan.

Gramineae
Imperata cylindrica (L.) Beauv. Frequent on disturbed, moist soil. Fl. Nov.–May.
Eulalia villosa (Thunb.) Nees. Common in grassland. Fl. Sep.–Dec.
Coelorhachis capensis Stapf. Rocky grassland. Fl. Sep.–Mrch.
Trachypogon spicatus (L.f.) Kuntze. Rocky grassland. Fl. Nov.–Mrch.
Elyonurus argenteus Nees. Rocky grassland. Fl. Aug.–Dec.
Andropogon amplectens Nees. Rocky grassland. Fl. Jan.–Feb.
A. eucomus Nees. Swampy places. Fl. Nov.–May.
A. shirensis Hochst. var. *angustifolius* Stapf. Grassland. Fl. Feb.–May.
Vetiveria zizanioides (L.) Nash. Hedge around old kraal. Fl. May.
Schizachyrium semiberbe Nees. Common in rocky grassland. Fl. Nov.–Mrch.
Cymbopogon excavatus (Hochst.) Stapf. Forest margin and rocky grassland. Fl. Dec.–May.
C. validus Stapf ex Burtt Davy. Forest margin and rocky grassland. Fl. Dec.–May.
Hyparrhenia filipendula (Hochst.) Stapf. Sub-dominant in grassland. Fl. Sep.–May.
H. gazensis (Rendle) Stapf. Rare in grassland.
Monocymbium ceresiiforme (Nees) Stapf. Common in trampled grassland. Fl. Feb.–Mrch.
Heteropogon contortus (L.) Beauv. Rocky grassland. Fl. Jan.–Mrch.
Sorghastrum rigidifolium (Stapf) L. Chippendall. Vlei grassland. Fl. Feb.
Themeda triandra Forsk. var. *imberis* (Retz.) A. Camus. Grassland uncommon. Fl. Feb.–Mrch.
Arundinella nepalensis Trin. Stream banks. Fl. Jan.–May.
Paspalum commersonii Lam. Open grassland, frequent. Fl. Oct.–May.
P. urvellei Steud. Vlei and swamps. Fl. Oct.–Mrch.
Pseudechinolaena polystachya (H.B.K.) Stapf. Swampy places. Fl. Mrch.
Panicum aequinerve Nees. Moist places. Fl. Feb.–Mrch.
P. deustum Thunb. Climber in forest margin. Fl. Sep.–May.
P. dregeanum Nees. Moist places. Fl. Nov.–Mrch.
P. maximum Jacq. Rocky grassland, common. Fl. Nov.–May.
Aloteropsis semialata (R. Br.) Hitchc. Rocky grassland. Fl. Aug.–Nov.
Brachiaria brizantha (Hochst.) Stapf. Grassland. Fl. Nov.–May.
B. humidicola (Rendle) Schweick. Grassland, frequent. Fl. Dec.–Feb.
B. serrata (Spreng.) Stapf. Rocky grassland. Fl. Sep.–Feb.
Echinochloa pyramidalis (Lam.) Hitchc. & Chase. Stagnant water. Fl. Feb.–May.
Sacciolepis curvata (L.) Chase. Forest floor, common. Fl. Feb.
Digitaria diagonalis (Nees) Stapf. Rocky grassland. Fl. Feb.
D. eriantha Steud. Sub-dominant in grassland. Fl. Feb.–Apr.
D. longiflora (Retz.) Pers. Rocky grassland, common. Fl. Nov.–Mrch.
D. macroglossa Henr. Grassland, common. Fl. Feb.–May.
D. pentzii Stent. Grassland, rare. Fl. Feb.
D. ternata (Hochst.) Stapf. Disturbed places. Fl. Dec.
Acroceras macrum Stapf. Vlei grassland, uncommon. Fl. Dec.
Rhynchelytrum repens (Willd.) C. E. Hubb. Disturbed grassland and fallow lands. Fl. Sep.–Jul.
R. setifolium (Stapf) Chiov. Grassland, rare. Fl. Feb.–May.
Oplismenus hirtellus (L.) Beauv. Forest floor, common. Fl. Feb.–May.

Setaria chevalieri Stapf ex Stapf & C. E. Hubb. Stream bank forest, common. Fl. **Feb.–Aug.**
S. rigida Stapf. Swamps. Fl. Feb.
S. sphacelata (Schumach.) Stapf & C. E. Hubb. ex M. B. Moss. Grassland, frequent. Fl. **Aug.–** May.
Stenotaphrum secundatum (Walt.) Kuntze. Pioneer in disturbed places. Fl. Sep.–Mrch.
Olyra latifolia L. Climber in swamp forest. Fl. Nov.–Mrch.
Leersia hexandra Sw. Swampy places, common. Fl. Dec.–Mrch.
Ehrharta erecta Lam. var. *natalensis* Stapf. Moist places. Fl. Sep.–Nov.
Aristida congesta subsp. *barbicollis* (Trin. & Rupr.) de Wint. Xerophytic, rocky, grassland. Fl. Feb.–May.
A. junciformis Trin. & Rupr. Dominant in grassland. Fl. Feb.–May.
Sporobolus africanus (Poir.) Robyns & Tournay. Grassland, common. Fl. Feb.–May.
S. pyramidalis Beauv. Rocky grassland, common. Fl. Feb.–Mrch.
Tristachya hispida (L.f.) K. Schum. Sub-dominant in grassland. Fl. Nov.–May.
Trichopteryx dregeana Nees. Moist places. Fl. Feb.–May.
Cynodon dactylon (L.) Pers. Trampled veld. Fl. Sep.–May.
Chloris gayana Kunth. Grassland. Fl. Nov.–May.
C. pycnothrix Trin. Disturbed places. Fl. Jan.–Mrch.
Tripogon abyssinicus Nees. Xerophytic pioneer on shallow soil.
Eleusine africana Kennedy O'Byrne. Disturbed places. Fl. Oct.–Feb.
Dactyloctenium australe Steud. Below trees in savannah veld, common. Fl. Aug.–Nov.
Phragmites mauritianus Kunth. Stream bed and stagnant water, dominant. Fl. Mrch.–May.
P. australis (Cav.) Trin. ex Steud. Stagnant swamp, dominant. Fl. Feb.–Jul.
Eragrostis capensis (Thunb.) Trin. Sub-dominant in grassland. Fl. Oct.–Mrch.
E. chapelieri (Kunth) Nees. Grassland, uncommon. Fl. Nov.–Mrch.
E. cilianensis (All.) Lutati. Vlei grassland. Fl. Apr.
E. curvula (Schrad.) Nees. Grassland, common. Fl. Oct.–May.
E. lappula Nees var. *lappula*. Vlei grassland. Fl. Feb.
E. pilosa (L.) P. Beauv. Pioneer on disturbed ground. Fl. Oct.–May.
E. racemosa (Thunb.) Steud. Common in rocky grassland. Fl. Oct.–Mrch.

Cyperaceae

Ascolepis capensis Ridl. Swampy soil. Fl. Sep.–Oct.
Cyperus albostriatus Schrad. Forest floor, common. Fl. Sep.–Dec.
C. corymbosus Rottb. Disturbed places. Fl. Feb.
C. distans L.f. Swampy places. Fl. Dec.
C. immensus C.B. Cl. Dominant in swamps. Fl. Sep.–Mrch.
C. isocladus Kunth. Pioneer of water pools. Fl. Sep.–Feb.
C. latifolius Poir. Swamps, sub-dominant. Fl. Dec.–May.
C. leptocladus Kunth. Forest floor. Fl. Dec.
C. longus L. Moist, rocky places. Fl. Nov.
C. obtusiflorus Vahl. Important component of trampled grassland. Fl. Oct.–Mrch.
C. papyrus L. Dominant in "papyrus" swamps. Fl. Jan.–May.
C. rupestris Kunth. Xerophytic pioneer on shallow soil. Fl. Oct.–Dec.
Pycreus macranthus C.B. Cl. Swampy places. Fl. Jul.
P. mundtii Nees. Moist places. Fl. Jul.–Oct.
P. polystachyos Beauv. Moist places. Fl. Jan.–Apr.
Mariscus capensis Schrad. Vlei grassland. Fl. Sep.–Jan.
M. dregeanus Kunth. Swampy forest floor. Fl. Oct.–Apr.
M. macropus C.B. Cl. Moist, shady places. Fl. Nov.–Feb.

M. sieberianus Nees. Moist places. Fl. Aug.–Dec.
M. vestitus C.B. Cl. Xerophytic pioneer on shallow soil. Fl. Sep.–Dec.
Kyllinga erecta K. Schum. Rocky grassland. Fl. Oct.–Apr.
K. elatior Kunth. Moist places. Fl. Nov.–Feb.
Fuirena hirsuta (Berg.) P. L. Forbes. Stream banks. Fl. Aug.–Apr.
Scirpus prolifer Rottb. Swampy soil. Fl. Aug.
Frimbristylis complanata (Retz.) Link. Swampy soil. Fl. Sep.–Dec.
F. dichotoma (L.) Vahl. Grassland. Fl. Nov.–Apr.
F. ferruginea (L.) Vahl. Vlei grassland. Fl. Dec.–Apr.
F. hygrophylla Gordon-Gray. Swampy soil. Fl. Aug.–Apr.
F. ovata (Burm. f.) Kern. Vlei and open grassland. Fl. Dec.–Jul.
Bulbostylis contexta (Nees) Gordon-Gray. Abundant in grassland. Fl. Aug.–Mrch.
Rhynchospora corymbosa (L.) Britton. Dominant in sedge swamp. Fl. Sept.–Mrch.
Scleria angusta Nees. Stream banks. Fl. Sep.–Apr.
S. natalensis C.B. Cl. Grassland. Fl. Nov.–Apr.
S. welwitschii C.B. Cl.
Schoenoxiphium sparteum Kük. var. *lehmannii* Kük. Swampy soil. Fl. Sep.–Jan.
Carex spicato-paniculata C.B. Cl. Stream bank and swamp. Fl. Oct.–May.

Palmae
Phoenix reclinata Jacq. Tree. Stream bank and swamp forest, common.
Hyphaene crinita Gaertn. Shrub. Rocky localities in grassland.

Araceae
Zantedeschia aethiopica (L.) Spreng. Herb. Swampy soil, common. Infl. white, Sep.–May.
Stylochiton natalense Schott. Herb. Mesophytic forest floor, uncommon. Infl. green, Oct.–Dec.

Flaggelariaceae
Flaggelaria guineensis Schum. Climber in mesophytic forest, frequent. Fl. Nov.

Xyridaceae
Xyris anceps Lam. Herb. Swampy soil. Fls. yellow, Oct.–Jan.

Eriocaulaceae
Eriocaulon ruhlandii Schinz. Small herb. Swampy soil, rare. Fls. white, Nov.–Feb.

Commelinaceae
Commelina africana L. Trailing herb. Floor of stream bank forest. Fls. yellow, Aug.
C. africana var. *krebsiana* Kunth. Trailing herb. Moist soil. Fls. yellow, Sep.
C. eckloniana Kunth. Herb. Grassland and forest margin. Fls. blue, Sep.–Feb.
Aneilema aequinoctiale (Beauv.) Kunth. Trailing herb. on forest floor. Fls. yellow, Nov.–May.
A. hockii De Wild. Trailing herb on forest floor. Fls. blue, Dec.
A. schlechteri K. Schum. Climber in stream bank forest.
Murdannia nudiflora (L.) Brenan. Herb. Swampy soil. Fls. blue, Jul.
Cyanotis speciosa (L.f.) Hassk. Herb. Rocky grassland, common. Fls. mauve, Oct.–Feb.
Floscopa glomerata Hassk. Herb. Swampy soil. Fls. pale blue, Mrch.

Juncaceae
Juncus kraussii Hochst. Herb. Stream banks and flood sands. Fl. Nov.–Jan.
J. lomatophyllus Spreng. Herb. Swampy soil, frequent. Fl. Sep.–Mrch.

Liliaceae

Anthericum saundersiae Bak. Herb. Stream bank forest. Fls. white, Jul.–Sep.
Trachyandra asperata Kunth. Herb. Grassland. Fls. white, Sep.–Oct.
T. gerrardii (Bak.) Oberm. Herb in grassland. Fls. white, Sep.–Oct.
T. saltii (Bak.) Oberm. Succulent herb in rocky grassland. Fls. white, Jul.–Sep.
Chlorophytum krookianum Zahlbr. Herb in vlei grassland. Fls. white, Oct.–Mrch.
Eriospermum cooperi Bak. Herb in grassland. Fls. white-green, Sep.–Nov.
Kniphofia laxiflora Kunth. Herb in vlei grassland and swamps. Fls. yellow, May–Aug.
Aloe arborescens Mill. Succulent shrub. Rocky places. Fls. red, Jul.–Aug.
A. cooperi Bak. Succulent. Marshy places. Fls. orange-green, Dec.–Feb.
A. marlothii Berger. Succulent. Rocky grassland, common. Fls. yellow, green or red, Jul.–Aug.
A. saponaria (Ait.) Haw. Succulent. Grassland, common. Fls. red, Jul.
A. umfoloziensis Reyn. Succulent. Grassland, Fls. red, Jul.
Albuca setosa Jacq. Herb in grassland. Fls. white, Jul.–Aug.
Drimia alta R. A. Dyer. Herb in grassland. Fls. purple, Sep.–Oct.
Dipcadi marlothii Engl. Herb in grassland. Fls. green, Dec.–Feb.
D. viride (L.) Moench. Herb in grassland. Fls. brown-yellow, Dec.–Feb.
Ledebouria cooperi (Hook. f.) Jessop. Herb in grassland. Fls. pink-mauve, Aug.–Oct.
L. floribunda (Bak.) Jessop. Herb in rocky grassland. Fls. maroon, Aug.–Oct.
L. sp. Herb in rocky grassland. Fls. Oct.
Scilla natalensis Planch. Herb in grassland. Fls. blue, Aug.–Oct.
S. nervosa (Burch.) Jessop. Herb in rocky grassland. Fls. white, Sep.–Nov.
Drimiopsis maculata Lindl. Herb on forest floor. Fls. white-green, Sep.–Nov.
Dracaena hookeriana K. Koch. Shrub in stream bank forest, frequent. Fls. white, Nov.–Dec.
Sansevieria guineensis (L.) Willd. Woody herb in scrub thicket.
Asparagus densiflorus (Kunth) Jessop. Shrub in grassland scrub.
A. falcatus L. Climber in mesic forest. Fls. white, Oct.–Nov.
A. macowanii Bak. var. *zuluensis* (N.E. Br.) Jessop. Shrub in rocky grassland. Fls. white, Sep.
A. racemosus Willd. Shrub in rocky grassland.
A. setaceus (Kunth) Jessop. Climber in mesic forest.
Smilax kraussiana Meisn. Climber in forest, common. Fl. Dec.

Amaryllidaceae

Haemanthus albiflos Jacq. Herb in stream bank forest. Fls. white, Aug.
H. albomaculatus Bak. Herb in stream bank forest and rock crevices. Fls. white, Aug.
H. katherinae Bak. Herb on swamp forest floor. Fls. red, Aug.
Apodolirion buchananii Bak. Herb in grassland. Fls. white, Jul.
Crinum macowanii Bak. Herb in vlei grassland. Fls. pale pink, Sep.–Oct.
Cyrtanthus breviflorus Harv. Herb in vlei grassland. Fls. yellow, Nov.–Dec.
C. contractus N.E. Br. Herb in grassland. Flowers appear after veld fires; red, Aug.–Sep.
Hypoxis argentea Harv. Herb in grassland, common. Fls. yellow, Jul.–Sep.
H. filiformis Bak. Small herb in grassland. Fls. yellow, Aug.
H. gerrardii Bak. Herb in stream bank forest. Fls. yellow, Aug.
H. rigidula Bak. Herb in rocky grassland. Fls. yellow, Oct.–May.
H. rooperi S. Moore. Herb in rocky grassland. Fls. yellow, Dec.–Apr.

Dioscoreaceae

Dioscorea cotinifolia Kunth. Climber in mesic forest. Fls. green-yellow, Sep.–Nov.
D. dregeana (Kunth) Dur. & Schinz. Climber in mesic forest. Fl. Oct.–Dec.

D. diversifolia Griseb. Climber n mesic forest.
D. sylvatica Eckl. Climber in mesic forest. Fls. yellow-green, Nov.–Apr.

Iridaceae

Dietes vegeta (L.) N.E. Br. Herb in stream bank forest. Fls. white, Oct.–Dec.
Aristea cognata N.E. Br. Herb in rocky grassland. Fls. blue, Oct.
A. woodii N.E. Br. Herb in grassland, common. Fls. deep blue, Sep.–Nov.
Hesperantha baurii Bak. Herb in grassland. Fls. pale yellow, Apr.
Dierama elatum N.E. Br. Herb in grassland. Fls. white, Nov.–Feb.
Crocosmia aurea Planch. Herb in stream bank forest. Fls. orange, Jan.–Mrch.
Gladiolus longicollis Bak. Herb in grassland. Fls. creamy-yellow, Oct.
Lapeirousia laxa (Thunb.) N.E. Br. Herb in grassland. Fls. red, Jul.–Nov.

Musaceae

Strelitzia nicolai Regel & Koern. Dominant in mesophytic forest. Fls. white-blue, Aug.–Dec.

Orchidaceae

Stenoglottis longifolia Hook f. Herb in stream bank forest. Fls. pink, Apr.–Jun.
Habenaria caffra Schltr. Herb in swampy places. Fls. green-white, Dec.
H. epipactidea Reichb. f. Herb in grassland. Fls. white, Dec.
Bonatea boltonii Bolus. Herb on damp soil. Fls. white-green, Nov.–Dec.
Satyrium longicauda Lindl. Herb in grassland. Fls. white-pink, Nov.
Disa polygonoides Lindl. Herb on swampy soil. Fls. yellow or red, Sep.–March.
Cf. *Polystachya* sp. Herb, growing in shade on rock.
Eulophia foliosa (Lindl.) Bolus. Herb on swampy soil. Fls. yellow-green, Oct.
E. parviflora (Lindl.) Hall. Herb on damp soil. Fls. yellow-brown, May–Aug.
E. petersii Reichb. f. Succulent herb in rocky, xerophytic grassland. Fls. green-brown, Nov.–Jan.
Cyrtorchis arcuata (Lindl.) Schltr. Epiphyte on trees, especially *Syzygium cordatum*. Fls. white, Nov.–Mrch.

DICOTYLEDONEAE

Myricaceae

Myrica serrata Lam. Shrub or tree in swamp forest, common. Fl. Jul.

Ulmaceae

Trema orientalis (L.) Blume. Tree in mesic forest. Fl. Nov.–Jan.
Chaetacme aristata Planch. Tree in mesic forest.

Moraceae

Ficus burtt-davyi Hutch. Tree in mesic forest. Fl. Jul.–Aug.
F. capensis Thunb. Tree, locally dominant in swamp forest. Fl. Sep.–Oct.
F. capreaefolia Del. Shrub on flood sands and stream banks. Fl. Mrch.–May.
F. craterostoma Warb. ex Mildbr. & Burrett. Tree in mesic forest, starting off as a hemi-epiphyte on other trees. Fl. Oct.
F. ingens (Miq.) Miq. Chasmophytic tree. Fl. Aug.–Jan.
F. natalensis Hochst. Tree in mesic forest, usually starting off as hemi-epiphyte on other trees. Fl. Nov.
F. petersii Warb. Tree in mesic forest. Fl. Sep.–Oct.
F. sonderi Miq. Chasmophytic tree. Fl. Sep.–Nov.

Urticaceae

Urera cameroonensis Wedd. Climber in kloof forest. Fl. Apr.
Australina acuminata Wedd. Herb on fallow land. Fl. Dec.

Proteaceae

Protea multibracteata Phill. Shrub in grassland on south facing slope of the valley. Fls. pink-white, Nov.–May.

Santalaceae

Thesium costatum A.W. Hill. Herb in grassland. Fls. white, Sep.–Nov.
T. gracilentum N.E. Br. Herb in grassland. Fls. white, Aug.–Sep.
T. natalense Sond. Herb in grassland. Fls. white, Aug.–Sep.
T. virens E. Mey. Herb in vlei grassland. Fls. Dec.–Jan.

Olacaceae

Ximenia caffra Sond. Tree in stream bank forest. Fl. Aug.–Oct.

Polygonaceae

Polygonum pulchrum Blume. Herb in swampy localities. Fls. white, Jan.–Mrch.
P. salicifolium Brouss. Herb in swamp forest. Fls. pink, Sep.–Jan.
Oxygonum sinuatum (Hochst. & Steud. ex Meisn.) Damm. Herb in mesic forest. Fls. white, Sep.—Nov.

Chenopodiaceae

Chenopodium ambrosioides L. Weed on fallow land. Fl. Mrch.
C. murale L. Weed in disturbed places. Fl. Sep.–Dec.

Amarantaceae

Amaranthus spinosus L. Weed on disturbed soil. Fl. Aug.–Sep.
Pupalia atropurpurea Moq. Herbaceous climber in stream bank forest. Fl. Nov.–Jan.
Achyranthes aquatica R. Br. Herb in disturbed places. Fl. Sep.–Jun.
Achyropsis avicularis (E. Mey. ex. Moq.) Hook. f. Herb in stream bank forest. Fl. Mrch.–Jun.
A. leptostachya Hook. f. Herb on flood sands of stream banks. Fl. Sep.–Jun.
Gomphrena celosioides Mart. Weed in disturbed places. Fl. Sep.–Feb.

Aizoaceae

Aizoon glinoides L.f. Succulent herb in rocky grassland. Fls. light-green, Nov.–Mrch.

Portulacaceae

Portulaca quadrifida L. Succulent herb on shallow soil. Fls. yellow, Nov.

Caryophyllaceae

Stellaria media (L.) Vill. Herb on moist soil. Fls. white, Aug.–Oct.
Silene burchellii Otth. Herb in grassland. Fls. white, Nov.—Mrch.

Nymphaeaceae

Nymphaea capensis Thunb. Pioneer in water. Fls. blue, Sep.–Feb.

Menispermaceae

Cissampelos mucronata A. Rich. Climber in forest margin. Fl. Nov.
C. torulosa E. Mey. ex Harv. Climber in forest, common.
Tinospora caffra (Miers) Troupin. Climber in forest. Fls. yellow-green, Dec.–Feb.

Anonaceae
Uvaria caffra E. Mey. ex Sond. Climber in forest. Fl. Dec.
Popowia caffra (Sond.) Benth. Shrub in mesic forest, common. Fl. Sep.
Anona senegalensis Pers. Tree in rocky grassland.

Cruciferae
Lepidium bonariense L. Weed of disturbed places. Fl. Sep.–Nov.
Coronopus didymus (L.) Sm. Weed of disturbed places. Fl. Aug.–Dec.

Capparidaceae
Maerua cafra (DC.) Pax. Tree in mesic forest. Fls. green, Sep.

Droseraceae
Drosera burkeana Planch. Herb on swampy soil, common. Fls. white-pink, Aug.–Feb.

Crassulaceae
Kalanchoe rotundifolia Haw. Succulent herb in rocky grassland. Fls. orange-red, Sep. May.
Crassula ericoides Haw. Succulent pioneer on shallow soil. Fl. Mrch.
C. heterotricha Schinz. Succulent pioneer on shallow soil. Fls. white, Apr.–May.
C. lineolata Dryand. Herb in shady, moist places. Fls. white, Sep.–May.
C. rubicunda E. Mey. Succulent herb in grassland. Fls. deep red, Apr.–Aug.

Rosaceae
Rubus rigidus Sm. Straggling shrub of forest margin. Fls. white, Aug.–Nov.

Leguminosae
Albizia adianthifolia (Schumach.) W. F. Wight. Dominant tree in mesic forest. Fls. white-green, Sep.
Acacia borleae Burtt Davy. Tree in grassland scrub.
A. caffra (Thunb.) Willd. Tree in scrub forest, common. Fls. creamy-yellow, Aug.–Oct.
A. karroo Hayne. Tree in mesic forest, frequent in places. Fls. yellow, Oct.–Jan.
A. robusta Burch. Tree in a stream bank forest. Fls. pale yellow, Aug.–Sep.
Dichrostachys cinerea (L.) Wight & Arn. subsp. *cinerea*. Shrub in scrub forest. Fls. pink-yellow, Oct.–Jan.
Elephantorrhiza elephantina (Burch.) Skeels. Low shrub in rocky grassland. Fls. pale yellow, Sep.–Oct.
Entada spicata (E. Mey.) Druce. Climber in mesic forest.
Cassia biensis (Steyaert) Mendonca & Torre. Small shrub in grassland. Fls. bright yellow, Oct.–Nov.
C. corymbosa Lam. Shrub in forest margin. Fls. yellow, May.
C. mimosoides L. Small shrub in grassland. Fls. pale yellow, Aug.–Oct.
Caesalpinia decapetala (Roth.) Als. Straggling shrub. Fls. yellow, Jul.–Oct.
Crotalaria capensis Jacq. Shrub on flood sands. Fls. yellow, Sep.–May.
C. distans Benth. Small shrub in grassland. Fls. yellow, Feb.
C. globifera E. Mey. Small shrub in grassland. Fls. yellow, Sep.–Feb.
C. lanceolata E. Mey. Woody herb in grassland. Fls. orange-yellow, Aug.–Feb.
C. mucronata Desv. Woody herb on stream banks.
C. natalensis Bak. f. Shrub in grassland. Fls. yellow, Dec.–May.
C. natalitia Meissn. Woody herb in grassland. Fls. yellow, Sep.
C. striata DC. Small shrub on flood sands. Fls. yellow, Mrch.
C. vasculosa Wall. (First record for South Africa). Woody herb in grassland. Fls. yellow, Jan.–Apr.

Argyrolobium rupestre (E. Mey.) Walp. Herb in grassland, common. Fls. yellow, Oct.–Mrch.

A. tomentosum (Andr.) Druce. Small shrub on stream banks. Fls. yellow, Apr.–May.

Indigofera alternans DC. Herb in grassland. Fls. red, Sep.–May.

I. heterophylla Thunb. Woody herb in grassland. Fls. maroon-red, Aug.–May.

I. hilaris Eckl. & Zeyh. Herb in grassland. Fls. maroon-red, Sep.–May.

I. sanguinea N.E. Br. Woody herb in grassland, common. Fls. maroon-red, Sep.–Mrch.

I. tristis E. Mey. Woody herb in grassland. Fls. red-purple, Sep.–May.

Tephrosia elongata E. Mey. Herb in grassland. Fls. yellow, pink or pink-brown, Oct.–Jul.

T. grandiflora (Ait.) Pers. Woody herb in grassland. Fls. mauve, Oct.–Mrch.

T. glomeruliflora Meisn. Woody herb in grassland. Fls. light purple, Mrch.–Sep.

T. longipes Meisn. Herb in grassland. Fls. yellow, Oct.–Apr.

T. macropoda (E. Mey.) Harv. Decumbent herb in grassland. Fls. mauve, Nov.–Dec.

T. polystachya E. Mey. Woody herb in grassland. Fls. mauve, Aug.–Mrch.

Sesbania bisponosa (Jacq.) W. F. Wight var. *bispinosa*. Tall annual woody herb of disturbed places. Fls. yellow with purple spots, Apr.–Sep.

Aeschynomene micrantha DC. Prostrate herb in grassland. Fls. orange-yellow, Oct.–Dec.

Zornia capensis Pers. Prostrate herb in grassland, common. Fls. yellow, Aug.–Apr.

Desmodium dregeanum Benth. Prostrate herb in grassland. Fls. blue or pink, Nov.–Feb.

D. hirtum Guill. & Perr. Prostrate herb in grassland. Fls. blue-purple, Jan.–Mrch.

D. canum (J. F. Gmel.) Schinz & Thell. Prostrate herb in grassland. Fls. purple-red, Sep.–Jan.

Pseudarthria hookeri Wight & Arn. Woody herb in forest margin. Fls. maroon, Sep.–Feb.

Alysicarpus vaginalis (L.) DC. Prostrate herb in grassland. Fls. red, Dec.

Dalbergia armata E. Mey. Liana in stream bank forest, frequent. Fls. white, Sep.

D. obovata E. Mey. Liana in swamp forest. Fls. white, Oct.

Abrus fruticulosus Wall. ex Wight & Arn. Prostrate herb in grassland. Fls. mauve, Mrch.

A. precatorius L. Climber in grassland scrub. Fls. purple, Nov.

Glycine javanica L. Climber in stream bank forest. Fls. white, Sep.–Mrch.

Erythrina humeana Spreng. Shrub in vlei grassland. Fls. red, Dec.–Jan.

E. lysistemon Hutch. Tree in mesic forest. Fls. red, May–Sep.

Canavalia bonariensis Lindl. Liana in swamp forest. Fls. blue-purple, Oct.–Feb.

Rhynchosia nervosa Benth. & Harvey. Prostrate herb in rocky grassland. Fls. yellow, Oct.–Dec.

R. sordida (E. Mey.) Schinz. Woody herb in grassland. Fls. yellow, Mrch.–May.

R. stenodon Bak. f. Climber in forest margin. Fls. yellow, Apr. (Typical aspect dominant in grassland scrub and along forest margins during April).

R. totta (Thunb.) DC. Prostrate herb in rocky grassland. Fls. yellow, Oct.–Apr.

Eriosema cordatum E. Mey. Prostrate herb in grassland. Fls. yellow, Oct.–Mrch.

E. distinctum N.E. Br. Woody herb in vlei grassland. Fls. yellow, Nov.

E. parviflorum E. Mey. Woody herb in grassland. Fls. yellow, Jul.–Apr.

E. psoraleoides (Lam.) G. Don. Woody herb in grassland. Fls. yellow, Aug.–Sep.

E. salignum E. Mey. Herb in grassland. Fls. yellow, Aug.–Nov.

E. squarrosum Walp. Herb in grassland. Fls. orange-yellow, Oct.

Vigna triloba Walp. Prostrate herb in moist grassland. Fls. blue-purple, Jul.–Dec.

V. vexillata (L.) Benth. var. *hirta* (Hook.) Bak. Climber in forest margin. Fls. purple, Oct.–Nov.

Sphenostylis angustifolia Sond. Herb in grassland. Fls. purple, Sep.

S. marginata E. Mey. Prostrate herb in grassland. Fls. mauve, Sep.–Nov.

Dolichos axillaris E. Mey. Climber in forest margin. Fls. pale yellow, Sep.–Dec.

Geraniaceae

Pelargonium luridum (Andr.) Sweet. Herb in grassland, common. Fls. pink, Oct.–May.

Oxalidaceae

Oxalis corniculata L. Weed on sandy soil. Fls. yellow, Aug.–Jan.
O. smithiana Eckl. & Zeyh. Herb in grassland. Fls. pink-mauve, Aug.–Jan.

Rutaceae

Fagara capensis Thunb. Tree in stream bank forest. Fls. creamy yellow, Nov.–Dec.

Burseraceae

Commiphora woodii Engl. Tree in mesic forest. Fls. yellow-green, Oct.

Meliaceae

Turraea obtusifolia Hochst. Shrub in mesic forest. Fls. white, sweet scented, Nov.
Ekebergia capensis Sparrm. Tree in mesic forest. Fls. grey, Aug.–Oct.
E. pterophylla (C.DC.) Hofmeyr. Low tree in stream bank forest. Fls. white, Sep.
Trichilia emetica Vahl. Tree in mesic forest. Fls. yellow-green, Aug.–Oct.

Polygalaceae

Polygala capillaris E. Mey. Small herb in vlei grassland. Fls. white, Dec.–Apr.
P. gerrardii Chod. Herb in grassland. Fls. purple-red, Feb.
P. uncinata E. Mey ex Meisn. Woody herb in rocky grassland. Fls. purple-green, Aug.–Jan.
P. hottentotta Presl. Woody herb in grassland. Fls. green-yellow, Nov.–May.
P. producta N.E. Br. Woody herb in vlei grassland. Fls. mauve, Nov.
P. virgata Thunb. Shrub in forest margin. Fls. mauve, Aug.–Dec.

Euphorbiaceae

Phyllanthus glaucophyllus Sond. Herb in grassland. Fl. Sep.
P. reticulatus Poir. Liana in grassland scrub. Fl. Nov.–May.
Antidesma venosum E. Mey. ex Tul. Sub-dominant tree in mesophytic forest. Fl. Nov.
Bridelia micrantha (Hochst.) Baill. Dominant tree in swamp forest. Fl. Sep.
Adenocline pauciflora Turcz. Herb in shady localities. Fl. Aug.
Macaranga capensis (Baill.) Sim. Tree in swamp forest. Fl. Jun.
Acalypha ecklonii Baill. Prostrate herb on forest floor. Fl. Nov.–Jul.
A. peduncularis E. Mey. ex Meisn. Herb in grassland, Fls. red, Sep.–Nov.
A. petiolaris Hochst. Herb on sandy soil. Fls. reddish, Sep.–Nov.
Ctenomeria capensis (Thunb.) Harv. ex Sond. Climber in stream bank forest. Fls. yellow-green, Sep.–Oct.
Ricinus communis L. Shrub or tree in stream bank scrub. Fl. Oct.–Feb.
Dalechampia kirkii Prain. Climber in mesic forest. Fls. yellow-green, Nov.–Dec.
Clutia abyssinica Jaub. & Spach var. *abyssinica*. Shrub in grassland. Fl. Jul.–Nov.
Sapium ellipticum (Hochst. ex Krauss) Pax. Tree in mesic forest. Fl. Sep; fruit Feb.
Euphorbia hirta L. Herb in grassland. Fls. whitish, Aug.–Dec.
E. hypericifolia L. Weed of disturbed places. Fl. Oct.

Anacardiaceae

Sclerocarya caffra Sond. Tree in mesic forest. Fls. red, Sep.
Harpephyllum caffrum Bernh. ex Krauss. Tree in mesic forest. Fl. Jul.; fruit Oct.
Protorhus longifolia (Bernh.) Engl. Tree in mesic forest. Fl. Jul.; fruit Sep.
Ozoroa paniculosa (Sond.) R. & A. Fernandes. Tree in rocky grassland. Fls. white, Oct.–Nov.
Rhus fraseri Schonl. in grassland. Fl. Feb.
R. macowani Schonl. Shrub in grassland.
R. nebulosa Schonl. Liana in mesic and hydric forest, common. Fl. Mrch.

R. rehmanniana Engl. Low tree in grassland scrub. Fl. Jan.
R. rupicola Wood & Evans. Low shrub in grassland scrub.

Celastraceae

Maytenus heterophylla (Eckl. & Zeyh.) N. Robson. Low tree in kloof forest. Fls. white, Aug.
M. nemorosa (Eckl. & Zeyh.) Marais. Shrub. Fls. white, May.
M. senegalensis (Lam.) Exell. Tree in rocky places. Fls. white, May–Aug.
Cassine eucleaeformis (Eckl. & Zeyh.) Kuntze. Tree in mesophytic forest. Fls. white-green, Mrch.

Hippocrateaceae

Salacia kraussii (Harv.) Harv. Small shrub in grass veld. Fls. yellow, Sep.–Oct.

Icacinaceae

Cassinopsis tinifolia Harv. Tree in mesophytic forest. Fls. white, Aug.–Nov.
Apodytes dimidiata E. Mey. ex Arn. Tree in mesophytic forest. Fls. white, Mrch.–Jan.

Sapindaceae

Cardiospermum halicacabum L. Climber in mesophytic forest. Fls. white, Aug.–Nov.
Allophylus melanocarpus (Sond.) Radlk. Shrub in mesophytic forest. Fl. Jan.
Deinbollia oblongifolia (Sond.) Radlk. Tree in mesophytic forest. Fls. yellow-green, Apr.–May.
Hippobromus pauciflorus (L.f.) Radlk. Shrub in mesophytic forest. Fls. white, Aug.

Melianthaceae

Bersama lucens Hochst. Tree in kloof forest. Fls. green-yellow, Mrch.

Rhamnaceae

Ziziphus mucronata Willd. Tree in mesophytic forest. Fl. Nov.
Scutia myrtina (Burm. f.) Kurz. Liana in stream bank forest. Fl. Feb.

Heteropyxidaceae

Heteropyxis natalensis Harv. Tree in stream bank forest. Fls. yellow-green, Mrch.

Vitaceae

Rhoicissus rhomboidea (E. Mey. ex Harv.) Planch. Liana in mesophytic forest. Fls. green, Nov.
Roicissus tomentosa (Lam.) Wild & Drumm. Liana in forest.
R. tridentata (L.f.) Wild & Drumm. Shrub in rocky grass veld. Fls. yellow-green, Sep.
Cissus quadrangularis L. Climber in forest margin. Fls. creamy yellow, Dec.
Cyphostemma cirrhosum (Thunb.) Desc. Creeper in grass veld scrub. Fls. yellow-green, Dec.
C. natalitius (Szyszyl.) Codd. Creeper in grass veld scrub. Fls. yellow, Sep.

Tiliaceae

Grewia occidentalis L. Tree in mesophytic forest. Fls. mauve, Aug.–May.
Truimfetta pilosa Roth var. *effusa* (E. Mey. ex Harv.) Wild. Woody herb in scrub. Fls. yellow, Mrch.
T. rhomboidea Jacq. Woody herb in scrub. Fls. yellow, Oct.–Mrch.
Abutilon mauritianum (Jacq.) Medik. Woody herb in the forest margin. Fls. yellow-orange, Mrch.
Malvestrum coromandelianum (L.) Garcke. Herb of disturbed places. Fls. yellow-orange, Sep.–Nov.
Sida cordifolia L. Woody herb of the forest margin. Fls. pale yellow, Mrch.
S. pseudocordifolia Hochr. Woody herb of the forest margin. Fls. yellow.
S. rhombifolia L. Woody weed on disturbed soil. Fls. yellow, Aug.–Nov.

Hibiscus aethiopicus L. Herb in grass veld. Fls. yellow, Oct.–Jan.
H. trionum L. Herb in grass veld. Fls. yellow, May–Aug.

Sterculiaceae

Melhania didyma Eckl. & Zeyh. Woody herb in grass veld. Fls. yellow, Nov.–May.
Dombeya burgessiae Gerr. ex Harv. Shrub of grass veld scrub and forest margin. Fls. rose pink, May.
D. cymosa Harv. Tree in mesophytic forest.
Waltheria indica L. Woody herb in grass veld. Fls. yellow, Dec.

Ochnaceae

Ochna arborea Burch. ex DC. Shrub in stream bank forest. Fls. yellow, Sep.
O. pulchra Hook. Shrub in stream bank forest. Fls. yellow, Aug.

Guttiferae

Hypericum aethiopicum Thunb. subsp. *sonderi* (Bredell) N. Robson. Herb in grassland. Fls. yellow, Sep.–Apr.
H. lalandii Choisy. Herb of marshland. Fls. yellow, Nov.–Dec.
Garcinia livingstonei T. Anders. Tree in rocky grassland. Fruit Nov.

Violaceae

Rinorea ilicifolia (Welw. ex Oliv.) Kuntze. Tree in swamp forest. Fruit Sep.

Flacourtiaceae

Rawsonia lucida Harv. & Sond. Tree in mesophytic forest. Fls. white, Sep.–Nov.
Oncoba spinosa Forsk. Tree in mesophytic forest. Fls. white, Sep.
Gerrardina foliosa Oliv. Tree of the forest margin. Fl. Feb.–Apr.
Trimeria rotundifolia (Hochst.) Gilg. Tree in mesophytic forest. Fl. Sep.–Oct.
Dovyalis rhamnoides (DC.) Harv. Shrub in kloof forest. Fls. red, Sep.

Passifloraceae

Adenia gummifera (Harv.) Harms. Liana in swamp forest. Fl. Nov.–Dec.

Achariaceae

Ceratiosicyos laevis (Thunb.) A. Meeuse. Climber in swamp forest. Fls. green, Oct.

Cactaceae

Rhipsalis baccifera (J. S. Mueller) Stearn. Epiphyte in forest. Fls. creamy yellow, Aug.

Thymelaeaceae

Peddiea africana Harv. Lower stratum tree in mesophytic forest. Fls. light green, Oct.–Jul.
Lasiosiphon anthylloides Meisn. Woody herb of the grassland. Fls. yellow, Jul.–Nov.
L. splendens Endl. Woody herb of grassland. Fls. yellow, Jul.–Nov.
Arthrosolen calocephalus (Meisn.) C. A. Mey. Woody herb of the grassland. Fls. white, Aug.–Mrch.
Englerodaphne ovalifolia (Meisn.) Phill. Shrub of mesophytic forest. Fls. yellow-green, Sep.

Lythraceae

Nesaea tolypobotrys Koehne. Herb of marshland. Fls. pink, Nov.

Myrtaceae

Psidium guajava L. Tree in grassland scrub. Fls. white, Oct.
Eugenia natalitia Sond. Shrub of the forest margin. Fls. white, Sep.–Oct.

Syzygium cordatum Hochst. ex Harv. & Sond. Dominant tree along stream banks. Fls. white, Sep.–Oct.

S. guineense (Willd.) DC. Tree of stream bank forest. Fls. white, Oct.

Eucalyptus maculata Hook. A grove of trees planted by the local inhabitants. Fls. white.

Melastomataceae

Dissotis canescens (Grah.) Hook. f. Woody herb on swampy soil. Fls. pink, Aug.–Mrch.

D. phaeotricha (Hochst.) Triana. Herb on swampy soil. Fls. pink, Dec.

Araliaceae

Cussonia natalensis Sond. Tree of stream bank forest.

C. krausii Hochst. Tree of mesophytic forest. Fls. green, Apr.–Jun.

C. spicata Thunb. Tree of grassland scrub and mesophytic forest. Fls. greenish, Aug.

Schefflera umbellifera Sond. Tree of swamp forest. Fl. Mrch.–Aug.

Umbelliferae

Centella coriacea Nannfd. Prostrate runner in grassland. Fl. Sep.–Mrch.

C. glabrata L. var. *natalensis* Adamson. Prostrate herb in grassland. Fl. Sep.–Dec.

Alepidea gracilis Duemmer var. *major* Weim. Herb in grassland. Fls. white, Dec.–Apr.

Pimpinella caffra (Eckl. & Zeyh.) Harv. Herb in grassland. Fls. white, Jan.

Peucedanum capense Sond. Herb in grassland. Fls. yellow, Mrch.

Myrsinaceae

Maesa lanceolata Forsk. Tree of swamp forest. Fls. white, Sep.–Nov.

Rapanea melanophloeos (L.) Mez. Tree of mesophytic forest. Fl. Aug.

Primulaceae

Anagallis tenuicaulis Bak. Herb in swampy places. Fls. white, Sep.–Nov.

Ebenaceae

Euclea crispa (Thunb.) Guerke var. *crispa*. Shrub in rocky grassland. Fruit Feb.–Mrch.

E. natalensis A.DC. Tree in mesophytic forest or low shrub in rocky grassland scrub. Fl. Sep.

Diospyros galpinii (Hiern) De Wint. Small shrub in grassland. Fls. creamy yellow, Oct.

D. lycioides Desf. subsp. *sericea* (Bernh.) De Wint. Shrub or low tree in forest margin. Fls. creamy yellow, Sep.

D. scabrida (Harv. ex Hiern) De Wint. var. *scabrida* de Wint. Shrub in stream bank forest. Fls. white, Aug.

D. simii (Kuntze) De Wint. Shrub of forest margin. Fls. creamy yellow, Oct.

D. villosa (L.) De Wint. Low tree of the forest margin. Fls. creamy yellow, Oct.

Oleaceae

Olea capensis L. subsp. *enervis* (Harv. ex C.H.Wr.) Verdoorn Tree in stream bank forest. Fls. white, Sep.

Jasminum multipartitum Hochst. Climber in grassland scrub. Fls. white, Aug.–Oct.

Loganiaceae

Strychnos spinosa Lam. Tree in grassland scrub. Fruit Dec.

Nuxia oppositifolia (Hochst.) Benth. Tree in stream bank forest and swamp forest. Fls. white, Oct.–Dec.

Gentianaceae

Sebaea sedoides Gilg. Herb in grassland. Fls. yellow, Sep.–Apr.

Chironia purpurascens (E. Mey.) Benth. & Hook. f. Herb in rocky grassland. Fl. Oct.–Jan.

Apocynaceae

Carissa macrocarpa (Eckl.) A.DC. Shrub in grassland scrub and forest margin. Fls. white, Aug.–Mrch.

C. tetramera (Sacleux) Stapf. Shrub in rock crevice. Fls. white, Jun.–Jul.

Tabernaemontana ventricosa Hochst. ex A.DC. Sub-canopy tree in swamp forest. Fls. white, fragrant, Sep.–Nov.

Voacanga thouarsii Roem. & Schult. Dominant tree in swamp forest. Fls. white, Nov.

Rauvolfia caffra Sond. Important tree in swamp forest. Fls. white, Aug.

Asclepiadaceae

Raphionacme elata N.E. Br. Herb on rocky soil. Fls. greenish, Oct.

R. hirsuta (E. Mey.) R. A. Dyer. Herb in grassland. Fls. purple, Aug.–Oct.

Xysmalobium involucratum (E. Mey.) Decne. Herb in grassland. Fls. greenish, Oct.–Jan.

X. undulatum (L.) Ait. f. Herb in grassland. Fls. green-yellow, Oct.–Jan.

Schizoglossum cordifolium E. Mey. Herb in grassland. Fls. Sep.–Oct.

S. macowanii N.E. Br. var. *tugelense* N.E. Br. Herb in rocky grassland. Rare. Fls. white, Dec.

Pachycarpus appendiculatus E. Mey. Herb in grassland. Fls. pale yellow, Oct.–Nov.

P. concolor E. Mey. Herb in grassland. Fls. brown-red, Oct.–Feb.

Asclepias flexuosa Schltr. Prostrate herb in grassland. Fls. pink-brown, Sep.–Feb.

A. physocarpa Schltr. Woody herb of disturbed places. Fls. white, Sep.–Nov.

Cynanchum ellipticum (Harv.) R. A. Dyer. Liana in mesophytic forest. Fls. white, May–Sep.

Sarcostemma viminale R.Br. Liana in mesophytic forest. Fls. white, Jan.–Mrch.

Secamone gerrardii Harv. ex Benth. & Hook. f. Climber in swamp forest. Fls. yellow-brown, Sep.–Nov.

Sisyranthus compactus N.E. Br. Herb in grassland. Fls. green-white, Nov.

Ceropegia linearis E. Mey. Climber in grassland scrub. Fl. Mrch.

Riocreuxia torulosa Decne. Climber in forest margin. Fls. white-green, Feb.

Huernia hystrix (Hook. f.) N.E. Br. Succulent pioneer on rock. Fls. maroon, Mrch.

Tylophora anomala N.E. Br. Liana in mesophytic forest. Fls. white, Sep.–Jan.

Telosma africana N.E. Br. Liana in stream bank forest.

Convolvulaceae

Convolvulus farinosus L. Climber in grassland scrub. Fls. white-pink, Aug.–Mrch.

Hewittia sublobata (L.f.) O. Kuntze. Trailing plant in grassland. Fls. pale yellow, Sep.–Nov.

Merremia tridentata (L.) Hall. f. subsp. *angustifolia* (Jacq.) Ooststr. Trailing herb in grassland. Fls. pale yellow, Feb.–Mrch.

Ipomoea cairica (L.) Sweet. Climber in swamp forest. Fls. maroon, Aug.–Sep.

I. pellita Hall. f. Trailing herb in grassland. Fls. maroon, Oct.–Feb.

I. wightii (Wall.) Choisy Climber in mesic forest. Fls. purple, Jun.–Aug.

Boraginaceae

Cynoglossum lanceolatum Forsk. Woody herb in kloof forest. Fls. white-blue, Dec.

Verbenaceae

Verbena bonariensis L. Woody herb on flood sands. Fls. mauve, Sep.–Nov.

V. tenuisecta Briq. Herb of disturbed places. Fls. purple, Sep.–Feb.

Lantana rugosa Thunb. Shrub in grassveld thickets. Fls. mauve, Sep.–Oct.

Lippia javanica (Burm. f.) Spreng. Woody herb in grassveld scrub. Fls. white, Sep.

Clerodendrum glabrum E. Mey. Tree in mesic forest. Fls. white, Feb.

C. myricoides (Hochst.) Vatke. Shrub in forest margin. Fls. purple, Aug.–Sep.

Labiatae

Leonotis dysophylla Benth. Woody herb of grassland. Fls. orange, Oct.–May.

Stachys aethiopica L. Herb in grassland. Fls. white, Aug.–Feb.

Hyptis pectinata Poit. Herb on stream bank. Fls. white, Jul.

Endostemon obtusifolius (E. Mey. ex Benth.) N.E. Br. Woody herb in forest margin. Fls. white, Sep.–Apr.

Pycnostachys reticulata (E. Mey.) Benth. Woody herb in vlei grassland. Fls. purple-blue, Apr.

Plectranthus tomentosus Benth. Woody herb in rocky grassland. Fls. mauve, Mrch.–Apr.

P. zuluensis T. Cooke. Woody herb on forest floor. Fls. purple-blue, Sep.–May.

Hoslundia opposita Vahl. Woody herb in grassland thicket. Fls. white, Jul.–Nov.

Syncolostemon argenteus N.E. Br. Woody herb in grassland. Fls. white, Jan.–Apr.

Ocimum canum Sims. Woody herb in disturbed grassland. Fls. white, Sep.–Nov.

Thorncroftia thorncroftii (S. Moore) L. E. Codd. Succulent on rocky habitat. Fls. pink, Oct.–Jan.

Solanaceae

Withania somnifera Dun. Woody herb in scrub thicket. Fls. yellow-green, Oct.–May.

Solanum mauritianum Scop. Tree in forest margin. Fls. purple, Sep.–May.

S. nigrum L. Herb of disturbed places. Fls. white, Aug.–May.

S. panduraeforme E. Mey. Weed of disturbed places. Fls. purple, Aug.–Dec.

S. sodomeum L. Woody herb in grassveld scrub. Fls. white, Sep.–Nov.

Datura ferox L. Woody herb of disturbed places. Fls. white, Feb.

Scrophulariaceae

Diclis reptans Benth. Trailing herb in grassland. Fls. white, Jul.–Sep.

Halleria lucida L. Tree in kloof forest. Fls. red, Aug.–Dec.

Manulea crassifolia Benth. Woody herb in grassland. Fls. orange, Aug.–Nov.

Zaluzianskya maritima Walp. Grassland herb. Fls. maroon, Aug.–Nov.

Lindernia nana (Engl.) Roessl. Herb in rocky places. Fls. white-mauve, Dec.

Ilysanthes dubia (L.) Bernh. Herb of vlei grassland. Fls. yellow, Jan.

Selago hyssopifolia E. Mey. Grassland herb. Fls. white, Aug.–Nov.

Alectra sessiliflora (Vahl) Kuntze. Semi parasitic herb in grassland. Fls. yellow, May.

A. orobanchoides Benth. Parasitic herb in rocky grassland. Fls. pale yellow, Mrch.–Apr.

Graderia scabra Benth. Grassland herb. Fls. pink, Sep.–Apr.

Sopubia simplex Hochst. Herb on marshy soil. Fls. pink, Nov.–Feb.

Buchnera glabrata Benth. Grassland herb. Fls. blue, Oct.–Feb.

Cycnium adonense E. Mey. Semi parasitic herb in grassland. Fls. white, Sep.–Nov.

Ramphicarpa tubulosa Benth. Semi parasitic herb in swampy grassland. Fls. white, Sep.–Dec.

Striga elegans Benth. Semi parasitic herb in grassland. Fls. red, Sep.

S. gesnerioides (Willd.) Vatke. Parasitic herb in rocky grassland. Fls. pink, Jan.

Bignoniaceae

Tecomaria capensis Spach. Shrub in kloof forest. Fls. orange, Jan.–May.

Pedaliaceae

Ceratotheca triloba E. Mey. Herb in rocky grassland. Fls. mauve, Sep.–Apr.

Lentibulariaceae

Utricularia livida E. Mey. Insectivorous herb in swampy habitat. Fls. pink, Aug.

Acanthaceae

Thunbergia atriplicifolia E. Mey. ex Nees Grassland herb. Fls. pale yellow, Oct.–Nov.

Phaulopsis imbricata (Forsk.) Sweet. Herb on forest edge and floor. Fls. white, Jun.–Sep.

Chaetacanthus setiger (Pers.) Lindl. Grassland herb. Fls. white, Oct.–Nov.
Ruellia cordata Thunb. Woody herb in rocky grassland. Fls. blue, Oct.–Nov.
Crabbea hirsuta Harv. Herb in rocky grassland. Fls. white, Jan.–Apr.
C. nana Nees. Herb in rocky grassland. Fls. white, Sep.
C. pedunculata N.E. Br. Herb in rocky grassland. Fls. white, Sep.
Barleria lancifolia T. Anders. Herb in rocky grassland. Fls. mauve, Dec.–Apr.
Crossandra greenstockii S. Moore. Grassland herb. Fls. orange, Oct.–Nov.
Asystasia gangetica (L.) T. Anders. Herb in forest margin. Fls. white, Sep.–Jan.
Hypoestis aristata R.Br. Herb on floor of swamp forest. Fls. pink, May.–Jun.
H. verticillaris R. Br. Herb on swampy soil. Fls. white, Apr.–Jun.
Justicia betonica L. Herb in stream bank vegetation. Fls. white, Jul.–Aug.

Rubiaceae

Agathisanthemum bojeri Klotzsch. Grassland herb. Fls. white, Feb.
Kohautia amatymbica Eckl. & Zeyh. Grassland herb. Fls. white, Sep.
Oldenlandia cephalotes (Hochst.) Kuntze. Trailing herb on swampy soil. Fls. white, Aug.–Jan.
O. affinis (Roem. & Schult.) DC. Herb in rocky grassland. Fls. purple, Nov.–Mrch.
O. herbacea (L.) Roxb. Herb in rocky grassland. Fls. white, Oct.–Nov.
Pentas angustifolia (A. Rich. ex DC.) Verdc. Grassland herb. Fls. blue, Feb.–Jun.
P. micrantha Bak. subsp. *wyliei* (N.E. Br.) Verdc. Woody herb in forest margin. Fls. white, Feb.
Burchellia bubalina (L.f.) Sims. Shrub in kloof forest. Fls. orange, Aug.–Nov.
Xeromphis obovata (Hochst.) Keay. Tree in kloof forest. Fls. white to creamy-white, Sep.–Nov.
Gardenia spatulifolia Stapf Hutch. Small tree in rocky grassland scrub. Fls. white, sweet scented; Sep.–Nov.
Kraussia floribunda Harv. Shrub in kloof forest. Fls. white, Oct.
Pentanisia prunelloides (Kl. ex Eckl. & Zeyh.) Walp. Grassland herb. Fls. blue, Oct.–Jul.
Vangueria infausta Burch. Tree in forest margin and thickets. Fls. green-yellow, Sep. Oct.
Canthium gueinzii Sond. Liana in swamp forest. Fls. white, Sep.–Oct.
C. ventosum (L.) S. Moore. Tree in mesic forest. Fls. green, Oct.
Pachystigma latifolium Sond. Grassland shrub. Fls. green, Oct.–Dec.
Pavetta delagoensis Brem. Shrub in rocky grassland. Fls. white, Dec.
P. edentula Sond. ex Harv. & Sond. Tree in rocky grassland. Fls. white, Nov.–Feb.
P. gracilifolia Brem. Shrub in rocky grassland. Fls. white, Oct.
P. lanceolata Eckl. Tree in stream bank forest. Fls. white, Oct.–Nov.
Psychotria capensis (Eckl.) Vatke. Shrub in stream bank forest. Fls. yellow, Sep.—Nov.
P. zombamontana (Knutze) Petit. Shrub in mesic forest.
Galopina circaeoides Thunb. Prostrate herb in moist places. Fls. white, Nov.–Mrch.
Anthospermum herbaceum L.f. Herb in rocky grassland. Fls. white, Dec.–Feb.
Richardia brasiliensis Gomez. Grassland herb. Fls. white, Sep.–Feb.
Diodia natalensis (Hochst.) K. Schum ex S. Moore & Garc. Grassland herb. Fls. white, Apr.–May.
Borreria scabra (Schum. & Thonn.) K. Schum. Herb in rocky grassland. Fls. white, Dec.
Rubia cordifolia L. Climber in scrub forest. Fls. white, May.

Dipsacaceae

Scabiosa columbaria L. Grassland herb. Fls. white, Aug.–May.

Cucurbitaceae

Kedrostis foetidissima (Jacq.) Cogn. Herbaceous climber in swamp forest. Fls. white, Sep.
Cucumis hirsutus Sond. Trailing herb in grassland. Fls. yellow, Sep.–Oct.
C. zeyheri Sond. Trailing herb in grassland. Fls. yellow, Sep.–Mrch.

Campanulaceae

Wahlenbergia caledonica Sond. Grassland herb. Fls. blue, Sep.–May.

Cyphia elata Harv. Grassland herb. Fls. yellow, Jan.–May.

Lobelia alata Labill. Grassland herb. Fls. blue, Sep.–Nov.

L. filiformis Lam. var. *natalensis* (A.DC.) E. Wimm. Herb of shady habitat. Fls. mauve-blue, Sep.–Nov.

Monopsis belliflora E. Wimm. Herb in swampy places. Fls. yellow, Sep.–Nov.

M. scabra (Thunb.) Urb. Herb in swampy places. Fls. brownish-purple, Nov.–Apr.

Compositae

Ethulia conyzoides L. Herb in stream bank vegetation. Heads mauve, Aug.–Sep.

Vernonia angulifolia DC. Climber in forest margin. Heads mauve, Dec.–Jun.

V. corymbosa (Thunb.) Less. Woody herb in grassland scrub. Heads purple-white, Feb.

V. hirsuta Sch. Bip. Grassland herb. Heads mauve, Aug.–Nov.

V. oligocephala (DC) Sch. Bip. ex Walp. Grassland herb. Heads mauve, Sep.–Oct.

V. capensis (Houtt.) Druce. Grassland herb. Heads purple, Jul.–Oct.

Adenostemma perrottettii DC. Herb on floor of swamp forest. Heads white, Jan.–Feb.

Ageratum conyzoides L. Herb on a swampy soil. Heads mauve, Jul.–Sep.

Mikania natalensis DC. Climber in swamp forest. Heads white, Mrch.–Aug.

Aster bakerianus Burtt Davy ex C.A.Sm. Grassland herb. Heads blue, Jul.–Oct.

A. lutea (N.E.Br.) Grassland herb. Heads yellow, Jul.–Oct.

Erigeron floribundus (H.B.K.) Sch. Bip. Herb of disturbed places. Heads pale yellow, Jan.

Nidorella auriculata DC. Grassland herb. Heads yellow, Jul.–Feb.

Conyza ulmifolia (Burm.) Kuntze. Grassland herb. Heads yellow, Jan.–May.

C. bonariensis (L.) Cronq. Herb of disturbed places. Heads pale yellow, Jan.

C. species (Venter 1417) Grassland herb. Fl. Dec.

Brachylaena discolor DC. Tree in mesic forest. Heads creamy-white, Jul.–Oct.

B. transvaalensis Phill. & Schweick. Tree in mesic forest. Heads creamy-white, Jul.–Oct.

Tarchonanthus galpinii Hutch. & Phill. Tree in rocky grassland. Fl. Sep.–Oct.

Blumea lacera DC. Grassland herb. Heads pink, Sep.–Dec.

Epaltes gariepina (DC) Steetz. Grassland herb.

Helichrysum adenocarpun DC. (Thunb.) Grassland herb. Heads white-red, Aug.–May.

H. adscendens Less. Grassland herb. Heads yellow, Aug.–Mrch.

H. appendiculatum (L.f.) Less. Grassland herb. Heads yellow, Sep.–Mrch.

H. callicomum Harv. Grassland herb. Heads yellow, Nov.

H. cooperi Harv. Herb in vlei grassland. Heads yellow, Nov.

H. decorum DC. Herb in rocky grassland. Heads yellow, Sep.–Apr.

H. griseum Sond. Herb in rocky grassland. Heads yellow-red, Aug.–Oct.

H. kraussii Sch. Bip. Grassland herb. Heads pale yellow, Jul.–Sep.

H. longifolium DC. Grassland herb. Heads pale yellow, Oct.

H. miconiaefolium DC. Grassland herb. Heads yellow, Sep.–Nov.

H. nudifolium (L.) Less. Grassland herb. Heads yellow, Aug.–Jan.

H. nodifolium (L.) Less. var. *quinquenerve* (Thunb.) Moeser. Grassland herb. Heads yellow, Aug.–Jan.

H. panduratum O. Hoffm. Grassland herb. Heads yellow-white, Nov.–Dec.

H. rugulosum Less. Grassland herb. Heads white-maroon, Oct.–May.

H. setosum Harv. Grassland herb. Heads yellow, Apr.–Jun.

Athrixia Phylicoides DC. Grassland herb. Heads light purple, Nov.–Jun.

Callilepis laureola DC. Grassland herb. Heads white, Aug.–Oct.

Acanthospermum australe (Loefl.) Kuntze. Weed of disturbed places. Fruiting Aug.–Feb.

A. hispidum DC. Weed of disturbed places. Fruiting Apr.

Xanthium spinosum L. Weed of disturbed places. Fl. Sep.–Dec.

Siegesbeckia orientalis L. Herb on disturbed soil. Heads yellow, Sep.–Dec.

Aspilia mossambicensis (Oliv.) Wild. Grassland herb. Heads orange-yellow. Sep.–Apr.

Spilanthes mauritiana (Rich. ex Pers.) DC. Herb on disturbed soil. Heads yellow, Sep.

Bidens pilosa L. Weed of disturbed places. Heads white, Sep.–Mrch.

Senecio bupleuroides DC. Grassland herb. Heads yellow, Sep.–Mrch

S. deltoideus Less. Climber in mesic forest. Heads yellow, May–Oct.

S. erubescens Ait. Grassland herb. Heads mauve-purple, Jul.–Nov.

S. erubescens Ait. var. *incisus* DC. Grassland herb. Heads mauve, Aug.–Nov.

S. latifolius DC. Grassland herb. Heads yellow, Sep.–Jan.

S. mikanioides Otto. Climber in kloof forest. Heads yellow, May–Sep.

S. oxyodontus DC. Grassland herb. Heads yellow, Apr.–May.

S. oxyriaefolius DC. Succulent herb in rocky grassland. Fl. Oct.

S. pterophorus DC. Grassland herb. Heads yellow, Sep.–Nov.

S. inaequidens DC. Grassland herb and weed of disturbed places. Heads yellow, Aug.–May.

S. serratuloides DC. Grassland herb. Heads yellow, Feb.–May.

S. tamoides DC. Climber in kloof forest. Heads yellow, May.

Euryops laxus (Harv.) Burtt Davy. Grassland herb. Heads yellow, Oct.

Osteospermum grandidentatum DC. Grassland herb. Heads yellow, Oct.–Nov.

O. imbricatum L. Grassland herb. Heads yellow, Aug.–Apr.

Chrysanthemoides monilifera (L.) T. Norl. subsp. *rotundata* (DC.) T. Norl. Shrub in grassland scrub. Heads yellow, Aug.–Dec.

Gazania krebsiana Less. subsp. *serrulata* (DC.) Roessl. Grassland herb. Heads yellow, Oct.

Berkheya bipinnatifida (Harv.) Roessl. Woody herb in grassland scrub. Heads white, Feb.–May.

B. discolor (DC.) O. Hoffm. & Muschl. Grassland herb. Heads yellow, Aug.–May.

B. insignis (Harv.) Thell. Grassland herb. Heads orange-yellow, Oct.

B. erysithales (DC.) Roessl. Woody herb in shrub thicket.

B. setifera DC. Grassland herb. Heads yellow, Oct.

B. speciosa (DC.) O. Hoffm. Grassland herb. Heads yellow, Aug.–Feb.

Cirsium vulgare (Savi.) Ten. Weed of disturbed places. Heads purple, Sep.–Apr.

Gerbera ambigua Sch. Bip. Grassland herb. Heads creamy yellow, Aug.–Sep.

G. natalensis Sch. Bip. Grassland herb. Heads white-purple, Aug.–Nov.

G. piloselloides (L.) Cass. Grassland herb. Heads yellow, Aug.–Oct.

Sonchus asper (L.) Hill. Grassland herb. Heads yellow, Jul.–Aug.

Lactuca capensis Thunb. Grassland herb. Fl. Aug.–Oct.

Crepis hypochaeridia (DC.) Thell. Herb in rocky grassland. Heads yellow, Aug.–Oct.

Tolpis capensis (L.) Sch. Bip. Grassland herb. Fl. Sep.

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BUCHU SEED GERMINATION

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Abstract

The possible causes of poor seed germination of Buchu (*Agathosma betulina* Pillans, *A. crenulata* Pillans) were investigated. It appears that harvesting of immature seed is the major contributory factor. More uniform germination can be obtained by pre-sowing exposure of the seeds to dry heat (20—40 min. at 80°C).

Uittreksel

BOEGOESAAD ONTKIEMING.
Die moontlike oorsake van swak saadontkieming van Boegoe (*Agathosma betulina* Pillans, *A. crenulata* Pillans) is ondersoek. Dit blyk dat die oes van onryp saad die hoof bydraende faktor is. Meer uniforme ontkieming kan verkry word deur die saad voor saai aan droe hitte (20—40 min by 80° C) bloot te stel.

Introduction

One of the major problems in establishing buchu (*Agathosma betulina* Pillans, *A. crenulata* Pillans) plantations is poor and protracted seed germination. As most seeds are eaten by mice and birds it is customary for growers to harvest the seed-capsules before they are completely mature and dehisce, scattering the seed. Normally growers either sow the seed in seedbeds for subsequent transplanting or alternatively the seeds are planted *in situ* on previously prepared land.

The results of some experiments which were conducted to determine the cause of poor seed germination are reported below.

Methods and Results

Seed collection

To determine whether poor seed germination is due to harvesting of unripe seeds, shoots of buchu plants located in plantations of three growers were enclosed in cheesecloth bags at the time the first capsules started to shed their seeds. The bags were left on the plants until all capsules had dehisced, and the seeds then collected. Seed samples harvested by the growers in the normal way served as controls.

Viability of representative seed samples was determined by the following methods: 1. Placement of seeds in deionised water followed by stirring and

determining the percentage of seeds which sink to the bottom. This is a fairly reliable method which in previous tests proved to be approximately 95 per cent accurate. 2. Removal of seed coat to determine whether the embryo is fully developed. 3. Exposure of embryos (seed coat removed) to a one per cent solution of 2, 3, 5-triphenyl tetrazolium chloride for 24 hours. Development of a red triphenyl formazone colour in the embryonic tissues indicates viability. 4. Germination of intact seeds on moist filter paper in Petri dishes using four replications of 25 seeds per dish. Seeds were allowed to germinate for three months in a growth cabinet at a 10 hour day temperature of 18°C and 14 hour night temperature of 10°C. These day-lengths and temperatures were chosen to simulate winter conditions.

The results of one of the viability tests employed in which the germination of seed samples harvested in the normal way by three growers are compared with those collected in the manner described above, are given in Table 1. Essentially similar results were obtained using methods one to three.

TABLE 1

Effect of harvest method on germination of buchu seed

	Origin of seed	
	Seed collected by grower *% Germination*	*Seed collected in cheesecloth bags* *% Germination*
Producer 1	40	81
,, 2	7	68
,, 3	10	85

Seed germination

In an effort to stimulate earlier and more uniform seed germination several recognised methods of treating seeds were tested on a sample of freshly harvested, viable seed as determined by the water submersion method. The following treatments were tested: 1. Moist stratification at 9°C for 1, 2 and 3 months respectively. 2. Immersion in concentrated sulphuric acid for 30 minutes, one and two hours, respectively. 3. Immersion in solutions of sodium bisulphite (2 per cent), sodium hydroxide (2 per cent in 50 per cent ethanol) and hydrogen peroxide (20 per cent), respectively for 24 hours. 4. Leaching in running water for three and six days, respectively. 5. Exposure to dry heat for different periods and at two temperatures. The same germination procedure as given above was used, each treatment comprising 100 seeds (25 per Petri dish) including a no-treatment control.

None of the treatments tested except dry heat, affected germination and the latter results are given in Table 2.

TABLE 2

Germination of buchu seed after three months following various heat treatments

Treatment	Percentage germination
Dry heat for 1 day at 50°C	55 ± 12
,, ,, ,, 2 days ,, ,,	50 ± 15
,, ,, ,, 3 ,, ,, ,,	25 ± 10
,, ,, ,, 5 min ,, 80°C	65 ± 16
,, ,, ,, 10 ,, ,, ,,	55 ± 13
,, ,, ,, 20 ,, ,, ,,	80 ± 13
,, ,, ,, 40 ,, ,, ,,	75 ± 9
Control – no treatment	40 ± 12

DISCUSSION

Poor germination of seed obtained by growers is probably due to the collection of unripe seeds containing abortive embryos. The buchu plant normally flowers over an extended period and seed capsules in different stages of development are to be found on the same plant when maturation commences. Unfortunately no conspicuous change in colour of the capsule occurs immediately before the seeds are shed. Consequently, in order to obtain a larger percentage of viable seeds attempts should be made to harvest at frequent intervals after the first capsules start to shed their seeds. Alternatively shoots or the whole plant can be enclosed in cheesecloth bags until most of the seed have been shed.

Normally buchu seeds commence germination two months and more after being sown. As can be seen from Table 2, heat treatment of the seed, particularly that of exposure to a temperature of 80°C for a period of 20 to 40 minutes, effectively stimulated germination. However, the results are somewhat misleading as the experiment was terminated after three months. Subsequent germination of seeds may still have continued even up to six months and longer, as is often encountered in seedbeds of producers. The important effect of heat treatment therefore is to stimulate germination over a shorter period with the advantage that more uniform and stronger seedlings are obtained at the time of transplanting.

A QUALITATIVE STUDY OF THE NODULATING ABILITY OF LEGUME SPECIES: LIST 2

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Abstract

215 species of legumes indigenous to Southern Africa were examined for root nodules. Only three species (belonging to the Caesalpinioideae) were consistently found to be without root nodules. Of the listed species, 207 had apparently not previously been examined for their ability to produce root nodules.

Uittreksel

'N KWALITATIEWE STUDIE VAN DIE VERMOË VAN PEULPLANTSOORTE OM WORTELKNOPPIES TE VORM.
215 peulplantsoorte wat inheems aan suidelike Afrika is, is vir wortelknoppies ondersoek. Op slegs drie spesies (lede van die Caesalpinioideae) is deurgaans geen knoppies aangetref nie. 207 van die gelyste plantsoorte is skynbaar nog nie van te vore vir wortelknoppies ondersoek nie.

Introduction

Apart from reports by Mostert (1955) and Grobbelaar et al (1967) little is known about the nodulating ability of the 1 400-odd legumes (Phillips, 1951) that are indigenous to the Republic of South Africa, South West Africa, Botswana, Lesotho and Swaziland.

In an attempt to remedy this state of affairs a long-term survey was initiated at this laboratory some years ago and the present paper presents information obtained since the previous report was published by Grobbelaar et al (1967).

Procedure

The procedure was identical to that published earlier in greater detail (Grobbelaar et al, 1967). Where possible, plants were examined in the field for root nodules. In other cases plants were grown from seed in pots containing nitrogen-poor media and their roots were examined periodically for nodules. If nodules did not form within a reasonable time, the substrate was enriched with *Rhizobium* suspensions from available cultures and/or with soil from the natural habitat of the plants when this was possible.

Annuals which failed to nodulate in at least three consecutive pot trials and perennials which did not nodulate within at least two years, were regarded as not being able to nodulate under local conditions.

Herbarium voucher specimens were prepared of all species tested. The specimens were identified at the Botanical Research Institute, Pretoria and deposited in the herbarium of the Department of General Botany, University of Pretoria.

Prof. and Mrs. Allen of the University of Wisconsin, U.S.A., have been compiling a card index of all available data regarding the nodulation of legumes for many years. The results of the present investigation are therefore regularly transmitted to them and they in turn indicate through personal correspondence whether other reports (published or personal) are available regarding the nodulating ability of the species concerned. The information obtained from the Allens is included in the present communication because it is especially valuable in cases where negative results have been obtained in different parts of the world for the same species, as this would suggest a suitable *Rhizobium* strain probably does not exist for the legume concerned.

RESULTS AND DISCUSSION

The species on which information is provided are listed in table 1. Although the species are listed alphabetically within the genera, the genera, tribes and sub-families are arranged according to the system of de Dalla Torre & Harms (1963). The present list contains only species which are indigenous to the

TABLE 1

LIST OF INDIGENOUS LEGUME SPECIES EXAMINED FOR NODULATION

Plant Species	Herbarium Specimen Number*
IMMOSOIDEAE	
Acacieae Benth.	
Acacia hebeclada DC. ssp. hebeclada	19366
A. nebrownii Burtt Davy	17694
A. polyacantha Willd. ssp. campylacantha (Hochst. ex Rich.) Brenan	17693
A. reficiens Wawra ssp. reficiens	24572
A. stuhlmannii Taub.	20619
A. welwitschii Oliv. ssp. delagoensis (Harms) Ross & Brenan	17729
CAESALPINIOIDEAE	
Cynometreae Benth.	
Colophospermum mopane (Kirk ex Benth.) Kirk ex J. Léon	18306
Amherstieae Benth.	
Schotia capitata Bolle	16121
S. latifolia Jacq.	16122
Cassieae Benth.	
Cassia capensis Thunb. var. keiensis Steyaert	17555

LIST OF INDIGENOUS LEGUME SPECIES EXAMINED FOR NODULATION

Plant Species	Herbarium Specimen Number*
PAPILIONATAE	
Sophoreae Spreng.	
Sophora inhambanensis Klotzsch	19166
Calpurnia intrusa (R.Br.) E. Mey	20729
C. villosa Harv.	16615
Podalyrieae Benth.	
Cyclopia genistoides (L.) R. Br. var. genistoides	22953
C. montana Hofm. & Phill. var. glabra Hofm. & Phill.	22907
Podalyria biflora (L.) Willd	19176
P. calyptrata (Retz.) Willd	17571
P. glauca (Thunb.) DC.	23677
P. sericea (Andrew) R. Br.	19174
Genisteae Bronn.	
Priestleya calycina L. Bolus	22900
P. elliptica DC.	22899
P. sericea E. Mey	16588
P. tomentosa (L.) Druce	22950
P. vestita DC.	21682
Borbonia lanceolata L.	17680
Rafnia amplexicaulis Thunb.	22932
R. angulata Thunb.	16613
R. crassifolia Harv.	16817
R. cuneifolia Thunb.	20906
R. elliptica Thunb.	16818
R. opposita Thunb.	16599
R. ovata E. Mey	16819
R. perfoliata E. Mey	16611
R. triflora Thunb.	22951
Lotononis calycina (E. Mey.) Benth.	22856
L. eriantha Benth.	18291
L. florifera Dümmer	17669
L. hirsuta Schinz	22857
L. involucrata Benth.	22799
L. laxa Eckl. & Zeyh. var. multiflora Dümmer	22927
L. peduncularis Benth.	22917
L. prostrata Benth.	22904
Pearsonia aristata (Schinz) Dümmer	16884
P. atherstonei Dümmer	16881
P. marginata Dümmer var. marginata	19192
P. podalyriaefolia Dümmer	16812
Lebeckia cytisoides Thunb.	22786
L. plukenetiana E. Mey.	22810
L. sericea Thunb.	22940
L. simsiana Eckl. & Zeyh.	22784
L. wrightii Bol.	21683
Wiborgia armata Harv.	16824
W. obcordata Thunb.	16600
Aspalathus abietina Thunb.	16610
A. acicularis E. Mey. ssp. acicularis	22920
A. acuminata Lam. ssp. acuminata	17691
A. albens L.	22796
A. alopecurus Benth.	17690
A. araneosa L.	16603
A. argyrophanes R. Dahlgr.	17689

TABLE 1—*continued*

LIST OF INDIGENOUS LEGUME SPECIES EXAMINED FOR NODULATION

Plant Species	Herbarium Specimen Number*
A. aspalathoides (L.) R. Dahlgr.	20918
A. asparagoides L.f. ssp. rubro–fusca (Eckl. & Zeyh.) R. Dahlgr.	17688
A. astroites L.	20915
A. biflora E. Mey	22800
A. bracteata Thunb.	16605
A. capensis (Walp.) R. Dahlgr.	22956
A. carnosa Berg	16594
A. cephalotes Thunb. ssp. cephalotes	16586
A. cephalotes Thunb. ssp. violacea R. Dahlgr..	16589
A. chenopoda L.	16593
A. ciliaris L.	16601
A. commutata (Vog.) R. Dahlgr.	16992
A. cordata (L.) R. Dahlgr.	16609
A. crassisepala R. Dahlgr.	17687
A. crenata (L.) R. Dahlgr.	21688
A. divaricata Thunb. ssp. divaricata	16607
A. ericifolia L. ssp. ericifolia	22902
A. ericifolia L. ssp. minuta R. Dahlgr.	18242
A. flexuousa Thunb.	17686
A. gerrardii Bol.	20733
A. hispida Thunb. ssp. hispida	16796
A. hystrix L.f.	17546
A. juniperina Thunb.	16797
A. lactea Thunb. ssp. adelphea (Eckl. & Zeyh.) R. Dahlgr.	16989
A. laeta Bol.	22878
A. laricifolia Berg. ssp. canescens (L.) R. Dahlgr.	17684
A. linearis (Burm. f.) R. Dahlgr. ssp. linearis	20905
A. linguiloba R. Dahlgr.	22870
A. macrantha Harv.	22802
A. microphylla DC.	16617
A. muraltioides Eckl. & Zeyh.	16591
A. nigra L.	22955
A. opaca Eckl. & Zeyh. ssp. opaca	17682
A. retroflexa L. ssp. retroflexa	16619
A. salteri L. Bol.	18274
A. sericea Berg. ssp. sericea	21679
A. spicata Thunb. ssp. neglecta (Salter) R. Dahlgr.	16799
A. spicata Thunb. ssp. spicata	18273
A. spinescens Thunb. ssp. lepida (E. Mey) R. Dahlgr.	22939
A. stenophylla Eckl. & Zeyh. ssp. garciana R. Dahlgr.	20917
A. teres Eckl. & Zeyh. ssp. teres	22801
A. ulicina Eckl. & Zeyh. ssp. ulicina	16800
A. uniflora L. ssp. uniflora	18254
Buchenroedera tenuifolia Eckl. & Zeyh. var. pulchella (E. Mey.) Harv.	17677
Dichilus strictus E. Mey.	16966
Melolobium alpinum Eckl. & Zeyh.`	17668
M. candicans Eckl. & Zeyh.	16985
M. microphyllum Eckl. & Zeyh.	17652
Crotalaria capensis Jacq.	18293
C. globifera E. Mey.	20731
Argyrolobium adscendens Walp.	16794
A. candicans Eckl. & Zeyh.	17549
A. lanceolatum Eckl. & Zeyh.	16982
A. patens Eckl. & Zeyh.	17551

TABLE 1—*continued*

LIST OF INDIGENOUS LEGUME SPECIES EXAMINED FOR NODULATION

Plant Species	Herbarium Specimen Number*
A. pumilum Eckl. & Zeyh. var. verum	18268
A. transvaalense Schinz	16795
Hypocalyptus sophoroides (Berg.) Druce	17641
Galegeae Bronn.	
Indigofera alternans DC.	16807
I. angustifolia L.	22791
I. bainesii Bak.	19370
I. bifrons E. Mey.	17557
I. brachystachya E. Mey	16808
I. burkeana Benth.	16962
I. cardiophylla Harv.	17638
I. comosa N.E. Br.	19449
I. coriacea Ait. var. cana Harv.	16810
I. cryptantha Benth. var. occidentalis Bak. f.	16967
I. cytisoides Thunb.	22914
I. daleoides Benth.	19454
I. delagoaensis Bak. f. ex Gillett	20903
I. digitata Thunb.	17559
I. dimidiata Vogel	22477
I. discolor E. Mey.	22929
I. dissimilis N.E. Br.	19434
I. egens N.E. Br.	18303
I. filicaulis Eckl. & Zeyh.	17674
I. filiformis Thunb.	17673
I. filipes Benth.	16928
I. flavicans Bak.	19480
I. garckeana Vatke	16887
I. gerrardiana Harv.	22891
I. glomerata E. Mey.	21687
I. hilaris Eckl. & Zeyh.	17672
I. holubii N.E. Br.	16934
I. humifusa Eckl. & Zeyh.	22811
I. laxeracemosa Bak. f.	22830
I. longipes N.E. Br.	22820
I. macra E. Mey.	19479
I. malacostachys Benth.	17560
I. melanadenia Benth.	17715
I. ovata Thunb.	20900
I. oxytropis Benth.	18283
I. oxytropoides Schltr.	22910
I. parviflora Heyne ex Wight & Arn. var. parviflora	16935
I. podophylla Benth. ex Harv.	19167
I. poliotes Eckl. & Zeyh.	17646
I. pretoriana Harms	23757
I. procumbens L.	17639
I. psoraleiodes L.	17640
I. reducta N.E. Br.	22826
I. rehmannii Bak. f.	16886
I. subulata Vahl. ex Poir.	19448
I. sulcata DC.	17558
I. swaziensis Bolus	16936
I. tenuissima E. Mey.	20909
I. tomentosa Eckl. & Zeyh.	22922
I. tristis E. Mey	16964

TABLE 1—*continued*
LIST OF INDIGENOUS LEGUME SPECIES EXAMINED FOR NODULATION

Plant Specis	Herbarium Specimen Number*
I. woodii Bol.	17671
I. zeyheri Spreng	18260
Psoralea aphylla L.	16814
P. asarina (Berg) Salter	17656
P. capitata Linn. f.	17655
P. cordata (L.) Salter	16602
P. decumbens Ait.	16815
P. fruticans (L.) Druce	16785
P. imbricata (L.f.) Thunb.	16604
P. laxa Salter	16616
P. oligophylla Eckl. & Zeyh.	17654
P. restioides Eckl. & Spach	20914
P. rotundifolia L.	22815
P. tomentosa Thunb.	18288
P. wilmsii Harms	16816
Tephrosia capensis (Jacq.) Pers. var. acutifolia E. Mey.	16965
T. linearis (Willd) Pers. ssp. discolor (E. Mey.) Gill.	17665
T. polystachya E. Mey. var. latifolia Harv..	16889
T. semiglabra Sond.	18265
T. sparsiflora H. M. Forbes	16974
T. tzaneenensis H. M. Forbes	16932
Lessertia depressa Harv.	17648
L. harveyana Bolus	17650
L. harbacea (L.) Druce	17670
L. incana Schinz	22946
L. perennans DC. var. polystachya (Harv.) L. Bolus	20730
L. rigida E. Mey.	22905
L. thodei Bolus	22908
Hedysareae DC.	
Aeschynomene nodulosa (Bak.) Bak. f.	21490
A. nyassana Taub.	16939
Stylosanthes fruticosa (Retz) Alston	16173
Phaseoleae Bronn.	
Rhynchosia adenodes Eckl. & Zeyh.	17663
R. angulosa Schinz.	16821
R. capensis (Burm.) Schinz	17658
R. caribaea (Jacq.) DC. var. picta (E. Mey.) Bak. f.	17762
R. clivorum S. Moore	16956
R. densiflora DC.	20901
R. erecta DC.	17675
R. komatiensis Harms	16937
R. minima (L.) DC. var. prostrata (Harv.) Meikle	16973
R. monophylla Schltra.	16614
R. nervosa Benth. var. petiola Burtt Davy	18296
R. pentheri Schltr. var. pentheri .	22903
R. thorncroftii (Bak. f.) Burtt Davy	18298
E. kraussianum Meisn.	20735
E. polystachyum Bak.	16804
E. salignum E. Mey.	17642
E. villosum (Meisn.) C.A. Smith ex Burtt Davy	20734

* Voucher herbarium specimens deposited in the herbarium of the Dept. of General Botany, University of Pretoria, Pretoria.

Republic of South Africa, S.W. Africa, Botswana, Lesotho and or Swaziland. Of the 215 species listed in table 1 only the first nine were tested in pot experiments; the observations on the others were made in the field.

Root nodules were found on all the species except *Colophospermum mopane*, *Schotia capitata* and *Schotia latifolia*—three of the four members of the Caesalpinioideae investigated. According to the Allens, *Schotia latifolia* was previously investigated by other workers for nodulation and these workers also failed to observe any. No record appears to exist of a previous investigation concerning the nodulating ability of *Colophospermum mopane* or *Schotia capitata*.

Of the species listed in table 1 on which nodulation was observed in the present study, *Lebeckia simsiana*, *Indigofera alternans*, *Indigofera cryptantha* var. *occidentalis*, *Indigofera macra*, *Indigofera oxytropis*, *Indigofera subulata*, *Aeschynomene nodulosa* and *Rhynchosia erecta* were previously investigated for nodulation. All of them were found to produce root nodules (Allen & Allen, Personal Communication). According to the Allens, the remaining 207 species on which nodulation was observed in the present study, have not been previously examined for this ability.

Although certain members of the Mimosoideae and Papilionatae appear to be unable to nodulate, the available information indicates that it is especially members of the Caesalpinioideae which lack this ability (Allen & Allen, 1961; De Souza, 1966; Grobbelaar et al, 1967). The negative results that were obtained with the three species from this sub-family during the present study therefore conform with the overall picture which emerged from earlier studies.

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STUDIES IN THE BULBOUS LILIACEAE IN SOUTH AFRICA: 3. THE MEIOTIC CHROMOSOMES OF *LEDEBOURIA*

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ABSTRACT

33 specimens of nine species of *Ledebouria* Roth were examined cytologically. Haploid numbers were found to be very variable within the species and no basic number can be proposed. Meoitic abnormalities were observed in very few specimens. No correlation was found between chromosome numbers and plant morphology.

UITTREKSEL

STUDIES VAN DIE BOLDRAENDE LILIACEAE IN SUID-AFRIKA:
3 DIE MEÏOTIESE CHROMOSOME VAN *LEDEBOURIA*.

33 Monsters van nege soorte *Ledebouria* Roth was sitologies bestudeer. Dit is bevind dat haploïde nommers binne die soort baie veranderlik kan wees en geen basiese nommer kan voorgestel word nie. Meïotiese abnormaliteite word in 'n paar monsters aangetref. Geen korrelasie word tussen chromosoom nommers en plant morfologie gevind nie.

INTRODUCTION

Prior to the present author's report on *Ledebouria* cytology in 1970, only two papers, dealing with the chromosomes of South African members of this genus, had been published (Giménez-Martin, 1959, and Fernandes & Neves, 1962). Giménez-Martin reported a somatic number of 12 for *L. graminofolia* (Bak.) Jess. (sub *Scilla stenophylla*) and Fernandes & Neves reported a somatic number of 24 for *L. apertiflora* (Bak) Jess. (sub *S. linearifolia*). Three papers on *L. hyacinthina* (sub *Scilla indica*), which is an Indian species, give somatic numbers of 30, 44, 45, 46, 58 and 60 (Rao, 1953 & 1956, and Sheriff & Murthy, 1946).

The present study was undertaken to provide information which might be of value in determining relationships between *Ledebouria* and other genera in the bulbous Liliaceae, to assist in the subdivision of the genus and also to obtain information on the occurrence of abnormalities during meiosis.

METHODS

Pollen mother cells were used throughout the investigation. No fixation or other pre-staining treatments were employed. Anthers were dissected out of buds and sqaushed in lacto-propiono-orcein, prepared as described in Haskell & Wills (1968).

Material was either photographed or drawn under a camera-lucida. Measurements were taken from the photographs (employing where necessary photographs taken in different planes) or from the camera-lucida drawings. The drawings accompanying the photographs in this paper were drawn from the photographs, using sketches made from the original preparations.

Satellites and heterochromatic regions were not detected and centromeres were usually not identifiable. It was found that the chromosomes did not fall into natural size groups. In calculating average sizes the measurements for each complement were placed in decending order of size and it was assumed that chromosomes in equivalent position in the order in different cells were homologous. Drawings of leaves were made from herbarium material of the actual specimens employed in the cytological investigations.

RESULTS

Ledebouria cooperi (Hook. f.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
TRANSVAAL—2427 (Thabazimbi): Bakkerspas	*Jessop 1061* (GRA)	10	10
NATAL—3030 (Port Shepstone): Mgongongo tributary to Tsotsha River, Wickman's Farm, Port Shepstone	*Strey 9291* (GRA)	13	10
NATAL—2930 (Pietermaritzburg): Hella Hella	*Strey 9203* (GRA)	15	8

No evidence for abnormalities during meiosis was detected in *L. cooperi* during this survey, although apparently reliable counts of 12 and 14 had been obtained for *Strey 9291* previously (Jessop, 1970), which may indicate variability in number in different plants within the same population. (Figs. 1–3).

Ledebouria floribunda (Bak.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3325 (Port Elizabeth): Basson's Kloof, Zuurberg	*Bayliss BS/3920* (GRA)	10	8
NATAL—2831 (Eshowe): 1 mile south of Nkandla	*Jessop 1062* (GRA)	11	10
CAPE—3326 (Grahamstown): Woest Hill	*Jessop 1063* (GRA)	17	16

This population (*Jessop 1063*) is of plants somewhat intermediate between *L. floribunda* and *L. revoluta*. In general morphology they are closer to *L. revoluta*, but they have been placed in *L. floribunda* because of the large size of the bulbs (up to 100 mm or more long) and leaves (often 150–200 mm long). Evidence for polyploidy is inconclusive although the presence of multivalents was suspected.

NATAL—2930 (Pietermaritzburg): in forest along road	*Strey 9234* (GRA)	30	9
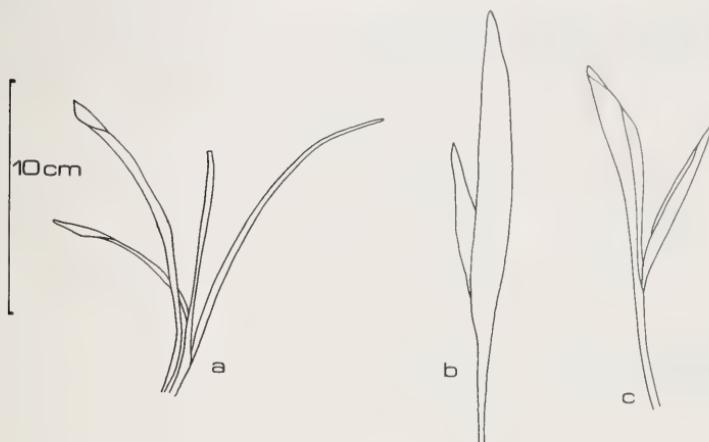
Fig. 1.
L. cooperi.
a. *Jessop 1061.* b. *Strey 9291.* c. *Strey 9203.*

Fig. 2.
Chromosomes of *L. cooperi* (*Strey 9291*).
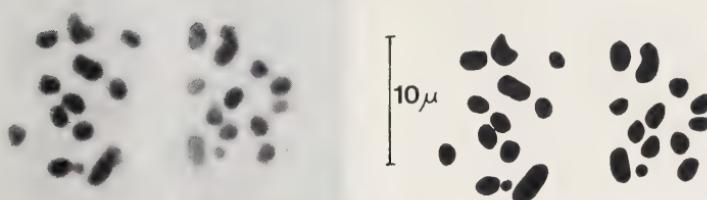
Fig. 3.
Chromosomes of *L. cooperi* (*Strey 9291*).

The only evidence for meiotic abnormalities in *L. floribunda* was suspected in *Jessop 1063*, which occurs in a district in which *A. revoluta* is frequent. It is possible that the specimen examined represents a polyploid or hybrid population involving *L. revoluta* but further evidence is needed. (Fig. 4).
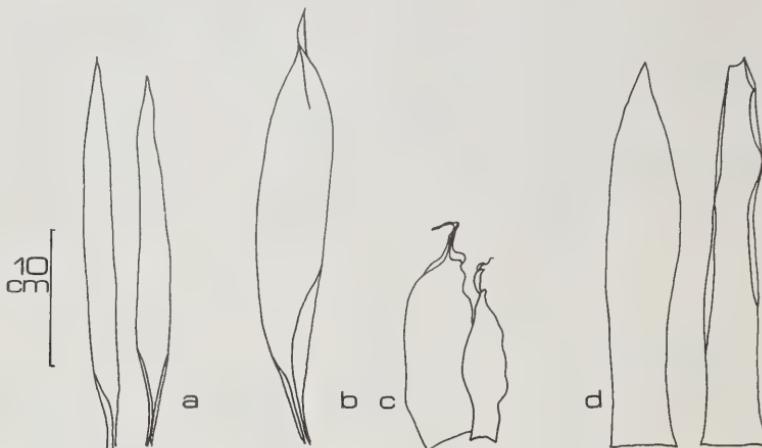

FIG. 4.
L. floribunda.
a. *Bayliss BS/3920.*   b. *Jessop 1062.*   c. *Jessop 1063.*   d. *Strey 9234.*
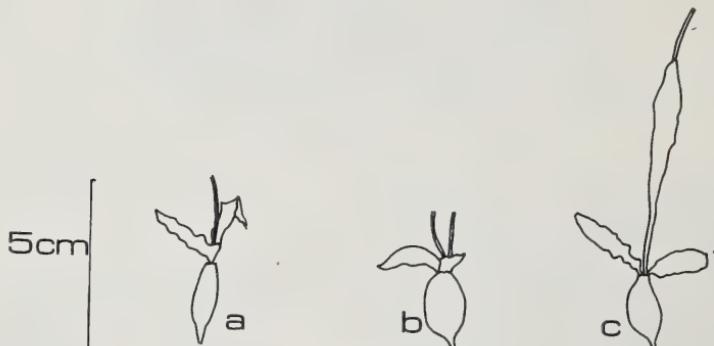
FIG. 5.
L. socialis.
a. *Tim* s.n.   b. *Bayliss BS/3806.*   c. *Bayliss BS/3224.*

Ledebouria socialis (Bak.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3326 (Grahamstown): Kariega	*Tim.* s.n. (GRA)	13	7
CAPE—3324 (Steytlerville): Andrieskraal, Baviaans Kloof	*Bayliss BS/3806* (GRA)	13	4
CAPE—3327 (Peddie): Wooldridge .	*Bayliss BS/3224* (RUH)	15	6

No meiotic abnormalities were detected in *L. socialis*, which is a particularly well-defined species, showing less morphological variation than do most species of *Ledebouria*. (Fig. 5)

Ledebouria concolor (Bak.) Jess.

| Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3326 (Grahamstown): Brooklands	*Bayliss BS/3377* (GRA)	18	6

(Fig. 6)
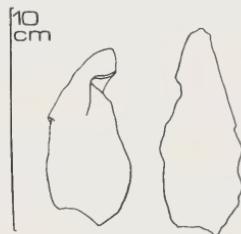
Fig. 6.
*L. concolor.* (*Bayliss BS/3377*).
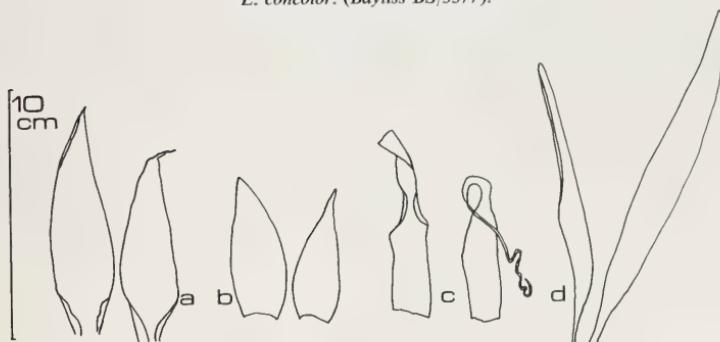
Fig. 7.
L. revoluta.
a. *Jessop 1064.*   b. *Bayliss BS/3296.*   c. *Strey 9292.*   d. *Jessop 1065.*

Ledebouria revoluta (L.f.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
Rhodes University garden, origin unknown	*Jessop 1064* (GRA)	1) 9	11
		2) 10	8
		3) 10	12

The above counts are each derived from the inflorescence of separate bulbs within a clone.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3325 (Port Elizabeth): Zuurberg, Henderson's Farm	*Bayliss BS/3296* (GRA)	10	14
NATAL—3030 (Port Shepstone): Mgongongo tributary to Tsotsha River, Wickman's Farm, Port Shepstone	*Strey 9292* (GRA)	10	11
TRANSVAAL—2428 (Nylstroom): 34 miles west of Potgietersrust . .	*Jessop 1065* (GRA)	1) 11	7
		2) 22	10

These two sets of data were obtained from different flowers on the same inflorescence. While N = c. 22 was found on another flower of the same inflorescence, no other flowers with N = c. 11 were found.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
NATAL—2829 (Harrismith): 5 miles west of Colenso	*Jessop 1066*	12	15
CAPE—3226 (Fort Beaufort): Kroomie	*Jacot Guillarmod* s.n. sub Rhodes Botany Dept Garden no. *167* (GRA)	13	14
NATAL—2831 (Eshowe): 7 miles south of Nkandla	*Jessop 1067* (GRA)	13	8
CAPE—3326 (Grahamstown): 2 miles north-west of Grahamstown	*Easton* s.n. sub Rhodes Botany Dept Garden no. *40* (RUH)	15	12
CAPE—3323 (Willowmore): Willowmore	*Bayliss BS/3887* (GRA)	16	12
SWAZILAND—2731 (Louwsberg): Ngwavuma	*Bayliss BS/3744* (GRA)	17	14

The only meiotic abnormalities recorded in *L. revoluta* were in *Jessop 1065*, where there appeared to be a reduction from N = 22 to N = 11. No explanation for a change of this type is suggested, but it is possible that the normal number is 11 with rather frequent polyploidy occurring. An additional count of N = 15 was reported by Jessop (1970) for a plant from a locality ten miles north of Pretoria. (Figs. 7 & 8)
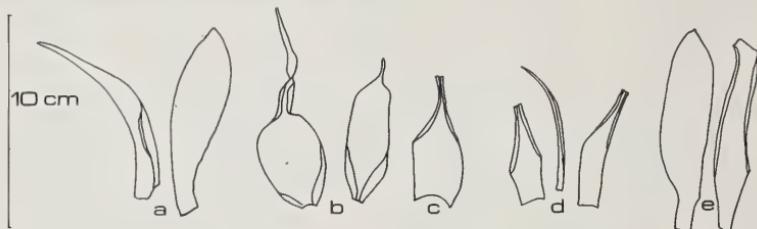

Fig. 8.
L. revoluta.
a. *Jacot Guillarmod* s.n.   b. *Jessop 1067.*   c. *Easton* s.n.   d. *Bayliss BS/3887.*   e. *Bayliss BS/3744.*

Ledebouria undulata (Jacq.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3327 (Peddie): Wooldridge .	*Bayliss BS/3224* (GRA)	10	10
CAPE—3323 (Willowmore): Willowmore	*Bayliss BS/3558* (GRA)	10	15
CAPE—3127 (Lady Frere): 18 miles west of Cala	*Jessop 1068* (GRA)	13	8
CAPE—3126 (Queenstown): Queenstown	*Bayliss* s.n. sub Rhodes Botany Dept Garden no. *178* (GRA)	14	15
CAPE—3326 (Grahamstown): Martindale	*Jessop 1053* (GRA)	15	14
CAPE—3325 (Port Elizabeth): Addo	*Bayliss* s.n. sub Rhodes Botany Dept Garden no. *179* (GRA)	c. 20 30	

Pairing (in *Bayliss* s.n. sub R.U.G. *179*) was irregular and laggards frequent. It is possible that this specimen is of a hybrid between *L. undulata* and *L. revoluta*, both of which are common and widespread in the area where it was collected. The leaves are rather narrow for the latter (up to about 8 mm broad) and rather linear. These characters suggest affinities with *L. cooperi* which is, however, very much less common. The bulb is distinctly of the *L. undulata* or *L. revoluta* type. (Figs 9—11)
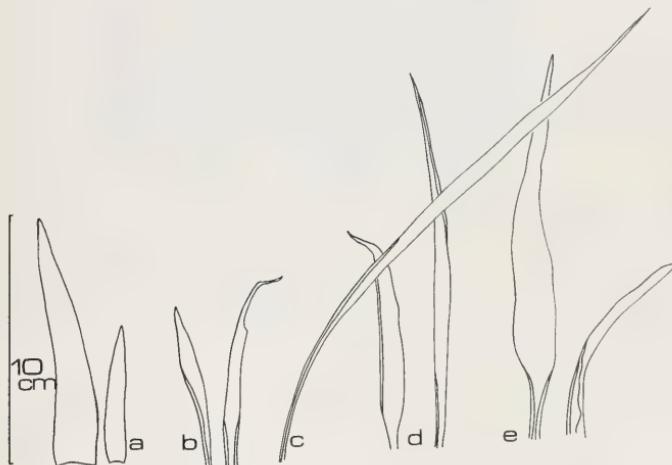

FIG. 9.
L. undulata.
a. *Bayliss BS/3224.* b. *Bayliss BS/3558.* c. *Jessop 1068.* d. *Bayliss* s.n. e. *Jessop 1053.*
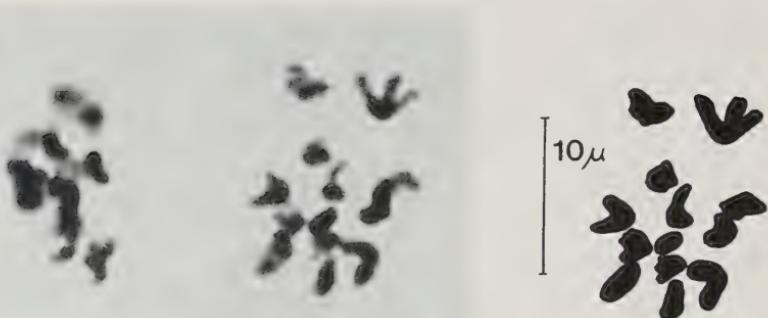
FIG. 10.
Chromosomes of *L. undulata* (*Jessop 1068*).
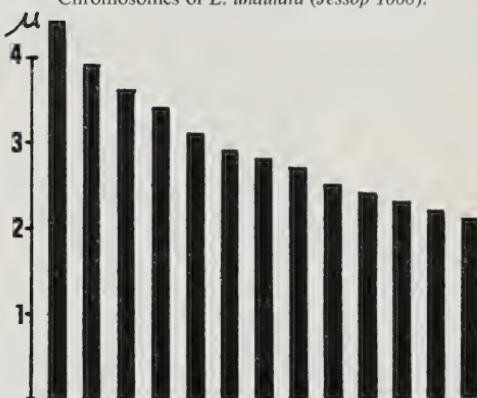
FIG. 11.
Chromosomes of *L. undulata* (Jessop *1068*).

Ledebouria marginata (Bak.) Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
CAPE—3127 (Lady Frere): Dordrecht	*Bayliss BS/3931* (GRA)	13	5

(Fig. 12a)

Ledebouria luteola Jess.

Locality	Collector, number, where housed	Haploid number	Number of cells counted
TRANSVAAL—2528 (Pretoria): 25 miles north of Pretoria	*Jessop 1057* (GRA)	46	4

(Fig. 12b)

Counts on sixteen cells varied from 39 to 56. Whether this only reflects the difficulties in counting a fairly large number of chromosomes or whether several haploid numbers existed could not be determined. (Fig. 12b)

Ledebouria ovatifolia (Bak.) Jess.

| Locality	Collector, number, where housed	Haploid number	Number of cells counted
NATAL—2930 (Pietermaritzburg): near Howick	*Jessop 1069* (GRA)	27	7

(Fig. 12c)
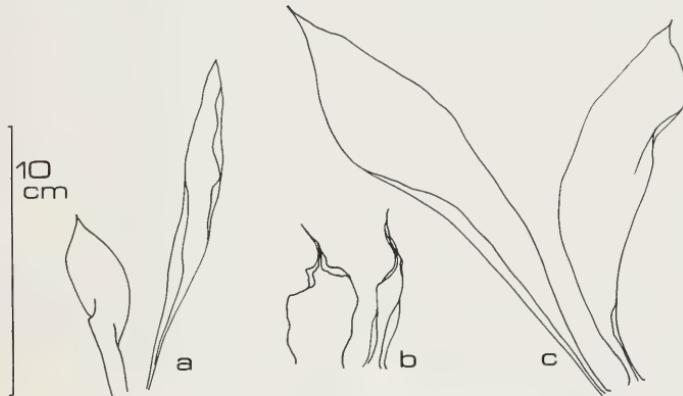
FIG. 12.
a. *L. marginata* (*Bayliss BS/3931*).   b. *L. luteola* (*Jessop 1057*).   c. *L. ovatifolia* (*Jessop 1069*).

DISCUSSION

The following numbers are reported in the genus *Ledebouria* (including those previously reported), all expressed as the haploid number:

Haploid number	Number of specimens whether of the same or different species
6	1
9	1
10	8
11	2
12	2
13	7
14	1
15	5
16	1
17	2
18	1
22	2
23	2 (and one with 2N = 45)
27	1
29	1
30	2
?46	1

No basic numbers are suggested by the data presented in this table. This is apparently a feature shared with *Scilla.* Darlington & Wylie (1955) report basic numbers of 4, 6, 7, 8, 9, 10 and 11 for *Scilla.* Similarly, the South African genus *Lachenalia,* which resembles *Ledebouria* to some extent in vegetative and floral characters, is reported as having basic numbers of 7, 8, 11 and 13. *Drimiopsis,* which is also a related genus occurring in southern Africa, has not been studied in detail, but does appear to have similar chromosome features (Jessop, 1972). On the other hand, *Muscari,* which is a northern hemisphere member of the Scilleae, appears to be very consistent, with a basic number of 9 indicated for all fifteen species recorded by Darlington & Wylie. Whether this great variability of number in *Ledebouria* is as a result of the frequent occurrence of B-chromosomes or whether the chromosomes tend to fragment and perhaps rejoin has not been established. There is, however, little evidence of abnormalities in pairing in meiosis. An examination of the measurements (not recorded in this paper) of the meiotic chromosomes suggests that the lengths of the chromosomes in a complement is not inversely proportional to the number of chromosomes as might occur if the greater numbers were simply produced by fragmentation.

The lack of chromosomal number consistency in the species of *Ledebouria* examined, and the lack of obvious basic numbers or simple polyploid series, reduces the potential value of these studies in determining relationships or evolutionary sequences in the genus or between it and other genera. There appears on the data so far available to be no correlation, either, between numbers of chromosomes and distribution.

The behaviour of the chromosomes is to some extent parallelled in the problems of defining the species of this genus. Both morphological and cytological characters appear to vary almost continuosly without producing well-defined groupings. It is possible that the chromosomal variation is linked with a reduced fertility. Seeds are set in a very small percentage (perhaps about 1 %) of flowers. Studies of embryo sac development are needed to establish whether or not development follows on fertilisation in the few fertile flowers. Hand pollination (both self and crossed) have failed to produce increased numbers of seeds.

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CHROMOSOME CYTOLOGY IN RELATION TO CLASSIFICATION IN *NERINE* AND *BRUNSVIGIA* (AMARYLLIDACEAE)

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ABSTRACT

The chromosome cytology of 16 species of *Nerine* and 3 of *Brunsvigia* was studied. A diploid number and similar karyotype was found in all species. Differences in position and shape of satellite were found which can be correlated with morphological characteristics. Karyotypes are compared to classification systems of *Nerine* and several inconsistencies are revealed in some treatments. *Brunsvigia marginata*, usually treated as a species of *Nerine*, is critically analysed. When the cytology of *Nerine* and *Brunsvigia* are compared, *B. marginata* is shown to have a karyotype similar to the latter genus.

UITTREKSEL

CHROMOSOOM SITOLOGIE IN VERHOUDING TOT DIE KLASIFIKASIE VAN *NERINE* EN *BRUNSVIGIA* (AMARYLLIDACEAE).
Die chromosoom sitologie van 16 *Nerine*, en 3 *Brunsvigia* soorte was bestudeer. 'n Diploïede getal en eenderse kariotipe was in al die soorte gevind. Verskille in posisie en fatsoen was in die satelliet gevind; dit kan in korrelasie staan met morfologiese kenmerke. Kariotipes word vergelyk met die klassifikasie sisteme van *Nerine* en etlike teenstrydighede word in party verhandelinge openbaar. *Brunsvigia marginata*, wat gewoonlik as 'n soort *Nerine* behandel word, word krities geanniliseer. As die sitologie van *Nerine* en *Brunsvigia* vergelyk word, word dit bewys dat *B. marginata* 'n kariotipe het wat eenders is as die laasgenoemde soorte.

INTRODUCTION

The genus *Nerine* probably comprises some 25 species, although the most recent treatment (Traub 1967) recognises 30 and 2 more species have since been described. While not all species could be obtained for the present study, a total of 16 species was examined, representing a good selection of the range of variation found in the genus. Some difference of opinion exists over the classification of *Nerine*, particularly at the subgeneric level. The number of species and the criteria used for classification vary considerably in different treatments. In view of this, the present author has made a cytological study of the genus in the hope that chromosomal characters might be discovered which could be linked to certain morphological features and establish the classification on a firmer basis. Previous workers had reported differences in the diploid number and in satellite position, so that further cytological investigation seemed promising. The species known currently as *N. marginata* is treated as a *Brunsvigia* as a result of this investigation, and two other species of this genus were studied for karyotype comparison.

MATERIALS AND METHODS

Except in a few cases it was not possible for the author to collect plants himself, but wherever possible plants were obtained from wild populations or from botanic gardens where species had not been long in cultivation, and the original locality was known, (table 1). With respect to the plants used in the study, Mr. G. McNeil and Mr K. Douglas and Kirstenbosch Botanic Gardens must be thanked for providing specimens.

Root tips were used to study mitotic metaphase. These were collected on warm afternoons. Cells were found to be actively dividing under such conditions. The root tips were pretreated in 0,05 % colchicine for four hours and then fixed in acetic-alcohol 1:3 for several minutes. After fixation they were stored in 70 % alcohol or macerated immediately in N HCl at 60°C for 6–8 minutes. Root apices were squashed in lacto-propionic orcein (A. F. Dyer 1963). Although preparations could readily be photographed (fig. 1), karyotypes were drawn with the aid of a camera lucida as this proved a more satisfactory method of representation. Idiograms were compiled from several karyotypes and hence represent the average rather than the single metaphase illustrated. The chromosomes in the idiograms are arranged in a sequence based on decreasing length
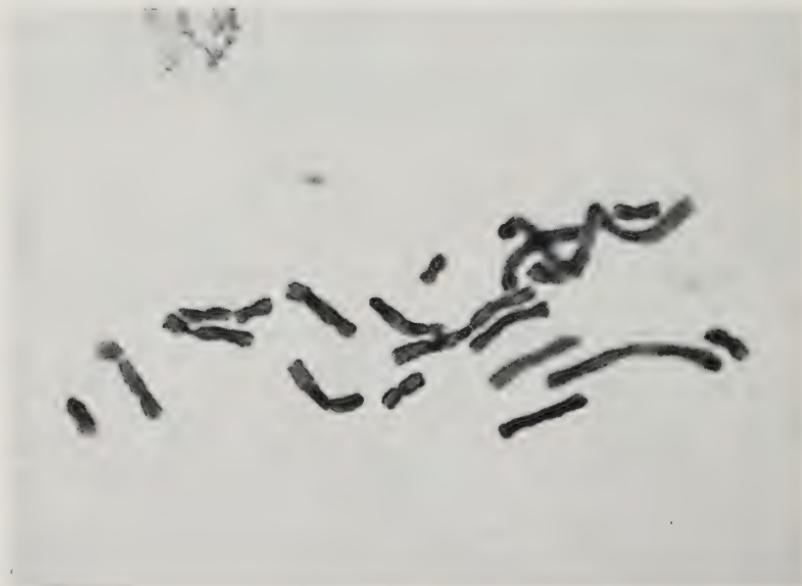

FIG. 1.

Metaphase in root tip cell of *Nerine angustifolia*. Satellites are visible on the two long chromosomes on the left.

except in the case where obvious homologues would otherwise be placed in different positions in comparable idiograms. To facilitate comparison the satellite is always shown above the centromere, whether located on the longer or shorter arm of the chromosome.

OBSERVATIONS

All species of *Nerine* and *Brunsvigia* examined proved to have a diploid number of 22. In general, the karyotypes were similar, all species having a pair
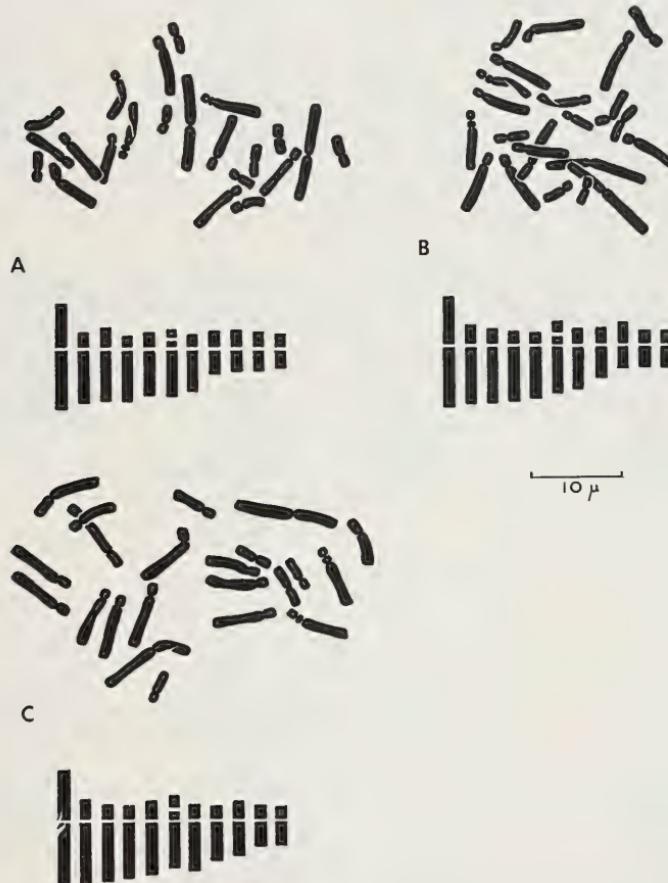
FIG. 2.
Metaphase and idiograms of *Brunsvigia*.
A. *B. appendiculata;*   B. *B. orientalis;*   C. *B. marginata.*

of very long, almost metacentric chromosomes, six pairs of somewhat smaller submetacentric to acrocentric shorter ones and four pairs of small chromosomes. Apart from minor differences in relative lengths of the arms of certain chromosomes, the position of the secondary constriction and the shape of the satellite were found to vary among different species of *Nerine* and *Brunsvigia*.

A. *Nerine*

Variation in shape and position of the satellite makes it possible to divide the genus into several categories.

Group 1.

In this group the satellite is located on one of the medium sized pairs of chromosomes, usually the sixth in order of length, (fig. 3: D, E, F; 4, 5). In the idiograms of this group, the satellite is always shown on the sixth chromosome though this is not always the sixth longest. It is sometimes not possible to measure chromosomes exactly, and chromosomes five and seven may occasionally be equal or very slightly longer than the sixth.

TABLE 1

List of species of *Nerine* and *Brunsvigia* studied, with diploid number and collecting data. Voucher specimens are housed at the Bolus Herbarium (BOL) or the Compton Herbarium (NBG), both at Cape Town, or at Kew Herbarium (K) London.

Species	Diploid No.	Collection Data
†Brunsvigia orientalis	2n = 22	Bettys Bay, C.P.
†B. appendiculata	= 22	Rietvlei, Clanwilliam, C.P. *Booysen* 6 (NBG).
B. marginata . . .	= 22	du Toits Kloof, C.P. *McMurtry s.n.* Kirstenbosch Gardens.
Nerine sarniensis . . .	= 22	Table Mountain, C.P.
N. flexuosa . . .	= 22	Cogmans Kloof, C.P. *Hall* 2736 (NBG).
	= 22	Keeromsberg, C.P.
N. humilis	= 22	Bains Kloof, C.P.
N. filifolia	= 22	Cold Spring, C.P. *Britten s.n.* (NBG 66395)
	= 22	Ft. Beaufort, C.P.
N. masonorum . . .	= 22	*Transkei (ex hort)*
†N. hesseoides . . .	= 22	nr. Vryburg, C.P. *Hutchison sub Goldblatt* (BOL).
†N. gibsonii . . .	= 22	Engcobo, C.P. *McNeil s.n.* (NBG 85056)
N. angustifolia . . .	= 22	Ermelo, Tvl. *McNeil s.n.* (K).
	= 22	Ficksburg, O.F.S. *McNeil s.n.* (NBG 88242).
N. platypetala . . .	= 22	Volksrust, Tvl. *McNeil s.n.* (NBG 88243).
†N. krigei . . .	= 22	Ermelo, Tvl. *McNeil s.n.*
N. undulata . . .	= 22	Morgans Bay road, C. P. *McNeil sub Goldblatt* (BOL).
†N. alta	= 22	Richmond, Natal.
N. cf. bowdenii . .	= 22	Mont aux Sources, Natal. *Trauseld s.n.* (PRE).
N. duparquetiana . .	= 22	Tuli Block, Botswana. *McNeil s.n.* (K).
N. laticoma . . .	= 22	nr. Vryburg, C.P. *McNeil s.n.* (K).
†N. huttonii . . .	= 22	Fish River valley, C.P. *McNeil, s.n.* (K).

* Plants studied were obtained from Kirstenbosch and are believed to be descendants of the type collection from the Transkei made by Canon and Miss Mason.
† Counts for these species are new records.

Fig. 3.

Metaphase and idiograms of *Nerine*.

A. *N. huttonii*; B. *N. laticoma*; C. *N. duparquetiana*; D. *N. sarniensis*; E. *N. humilis*;
F. *N. flexuosa*.

The outstanding feature of the group is that the satellite is always distinct and the primary and secondary constrictions are placed well apart, (table 2). Within the group there are clearly defined categories as described in table 2. These subdivisions of group 1 probably reflect close relationships of species but this is not necessarily so.

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TABLE 2

Comparison of karyotypes of species of *Nerine* studied.

</div>

GROUP 1. Satellite on chromosome 6.

      (i) Satellite and arms of chromosome subequal (Fig. 5).
         N. angustifolia   *N. platypetala*
         N. gibsonii
         N. krigei (borderline between this and the following category).
     (ii) Satellite and short arm of chromosome subequal, much smaller than the long arm; satellite attached to long arm (fig. 4: D, E, F.).
         N. bowdenii   *N. undulata*
         N. alta
    (iii) Satellite and short arm of chromosome much smaller than long arm; satellite small; satellite attached to short arm (fig. 3: D, E. F).
         N. humilis   *N. flexuosa*
         N. sarniensis
    (iv) Satellite small; arms of chromosome subequal (fig. 4: D, E, F).
         N. filifolia   *N. masonorum*
         N. hesseoides (borderline here, shows similarities with category (ii)).

GROUP 2. Satellite on a small chromosome; primary and secondary constrictions close together (fig. 3: A, B, C).

         N. duparquetiana   *N. laticoma*
         N. huttonii

Group 2

In the second group the satellite is located on the longest of the four pairs of short chromosomes (fig. 3: A, B, C.). The primary and secondary constrictions are very close together, and the satellite is much larger than the short arm of the chromosome. This group is also characterised by having very acrocentric chromosomes (except for the longest chromosome pair) and comprises: *N. huttonii*, *N. laticoma* and *N. duparquetiana*.

B. *Brunsvigia*.

In the three species studied the karyotypes are all similar, and bear a resemblance to *N. sarniensis* (fig. 2). The satellite, located on one of the medium chromosomes, is difficult to see, particularly if considerable shrinkage has occurred. The primary and secondary constrictions are close together, leaving a very narrow band of chromosome material between the constrictions representing the short arm of the chromosome. In this group the satellite, attached to the short arm of the chromosome is slightly larger than the short arm. Some difficulty was experienced in deciding which constriction was the centromere in

Fig. 4.
Metaphase and idiograms of *Nerine*.
A. *N. masonorum*;   B. *N. hesseoides*;   C. *N. filifolia*;   D. *N. undulata*;   E. *N. alata*;
F. *N. bowdenii*.

Brunsvigia. As will be seen from the idiograms (fig. 2), the constriction between the long arm and central segment of the chromosome is regarded as the centromere. This decision was taken purely on similarity of appearance of this constriction with other centromeres, but is not asserted with confidence.

Obviously, although *Brunsvigia* as represented here, is treated as karyotypically distinct, only a small difference in the relative sizes of the small arm and satellite separates the karyotype from group 1 (iii) of *Nerine* (table 2) especially *N. sarniensis*. It will be noted that if the centromere and secondary constriction are reversed, then *Brunsvigia* has a considerably more distinct karyotype.

DISCUSSION

Previous studies on the karyology of *Nerine* and *Brunsvigia*.

The early workers, before 1950 (table 3) were obviously not sure of the diploid number of *Nerine* and reported both 22 and or 24 for species. Satellites were only occasionally seen. Iniryama (1937) reported the typical long satellites in *N. undulata* while James and Addicott (1941) described *N. bowdenii* as having a very large satellite. Both these reports are confirmed here. Janaki Ammal (1951) surveyed the genus, including both natural species and hybrids, and reported the diploid number to be 22 with occasionally an extra chromosome pair in some individuals. Janaki Ammal provided no drawings and did not describe any satellites. Then, in Professor Gouws' study in 1954 and in a short report in 1971, the diploid number of 22 was agian confirmed, with an occasional record of 24. Satellites were reported in 5 of the 9 species he examined and their position is the same as reported in the present study.

In the absence of any records of 2n = 24 in this work, where, as far as possible, only wild populations were examined, the diploid number must be regarded as 22 only. Apparently, an extra chromosome pair occurs sporadically in cultivated plants and may be of the B type. Variation in chromosome number in cultivated plants is well known and material long in cultivation is automatically suspect.

There are two previous cytological records in *Brunsvigia*, that for *B. cooperi* (Gouws 1954) and for *B. marginata* (as Nerine) by Janaki Ammal (1951). The diploid number was reported as 22 but no satellites were described.

Correlation with systematic treatments of *Nerine*.

The first general treatment of the genus, that of Herbert (1837), divided the genus into two sections on the basis of the nature of the petals and stamens, erect or declinate, (table 4). The two main groups, *Regulares* (*N. sarniensis* and *N. marginata* only) and *Distortae* (including all other species known at that time), do not agree with observed cytological data on position and shape of the satellite.

The second classification, of Baker, which is best seen in Flora Capensis (1896) is not a formal one and sections are not recognised, (table 4). The treat-
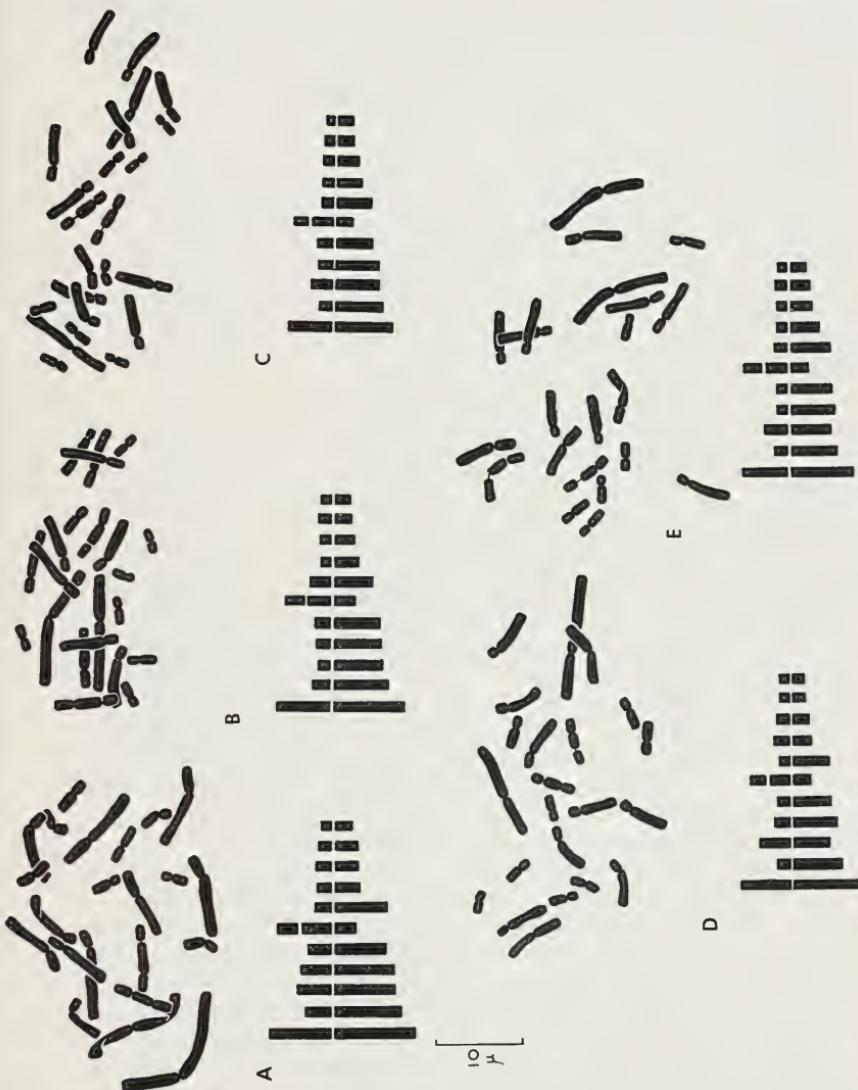
Fig. 5.
Metaphase and idiograms of *Nerine.*
A. *N. gibsonii;* B. *N. krigei;* C. *N. angustifolia* (Ficksburg); D. *N. platypetala;*
E. *N. angustifolia* (Ermelo).

TABLE 3

Chromosome numbers in *Nerine* as reported by various authors between 1926 and 1972. Numbers for hybrids and horticultural forms are not listed. Nomenclature is not corrected, but species now regarded as synonyms are in brackets under species in which they are now included.

Heitz (1926)		Janaki Ammal (1951)	
N. pusilla	n = 11 –(12)	N. angustifolia	2n = 22
N. sarniensis	= 11 –(12)	N. appendeculata	= 22
(N. curvifolia)	= 11	N. bowdenii	= 22, 24
N. undulata	ca 12	N. filifolia	= 22, 24
		N. flexuosa	= 22
		N. humilis	= 22
Sato (1936) (according to Iniryama 1937).		N. lucida	= 22
N. curvifolia	2n = 22	N. marginata	= 22
N. humilis	= 33	N. masonorum	= 22
		N. pudica	= 22
Iniryama (1937)		N. sarniensis	= 22, 24
N. flexuosa	2n = 33	(N. curvifolia)	= 22, 24
N. humilis	= 33	(N. moorei)	= 33
N. pudica	= 33	N. undulata	= 22
N. sarniensis	= 33		
(N. curvifolia)	= 33	Gouws (1954)	
N. undulata	= 22	N. duparquetiana	2n = 22
		N. falcata	= 22
		N. filifolia	= 24
James and Addicott (1941)		N. frithii	= 22
N. bowdenii	2n = 22 (–23)	N. laticoma	= 22
N. falcata	= 22 (–23)	N. masonorum	= 24
N. filifolia	= 24	N. sarniensis	= 22
N. flexuosa v. alba	= 22		
N. sarniensis var coruscans	= 22	Gouws (1971)	
(N. curvifolia var		N. angustifolia	2n = 22
fothergillii)	= 24	N. platypetala	= 22

ment does, however, clearly separate the genus into four groups. Group 1 consists of *N. sarniensis*, with erect stamens and a regular flower, but primarily with a slender peduncle. The criterion which is used to distinguish the fourth group is the presence of a thick peduncle, and it includes *N. marginata*, *N. laticoma* (as *N. lucida*) and *N. duparquetiana* (flowers declinate, or regular with erect stamens.) The remaining species fall into groups 2 and 3, both having a slender peduncle and declinate flowers. Group 3 is distinguished from group 2 on the basis of the presence or absence of filament appendages.

Clearly, cytological data are at odds with one aspect of this treatment, for the group with a short, thick peduncle is cytologically heterogeneous, *N. marginata* having a different karyotype and resembling *Brunsvigia* rather than *N. duparquetiana* and *N. laticoma*. With the removal of *N. marginata* to *Brunsvigia*, Baker's groups then appear to be natural and in accord with the cytological observations. The character of the thick peduncle then emerges as an important one in the subdivision of *Nerine* correlated as it is with differences in position of the satellite. The nature of the flower, either declinate or regular with erect stamens, assumes less importance, although it remains valuable in distinguishing *N. sarniensis*.

Lastly, whether or not the feature of appendaged stamens is a natural one, is not clear, for cytological observations reveal that the karyotypes are too similar in these two groups to facilitate classification.

TABLE 4
Early classification systems of *Nerine*.

After Herbert 1837

1. Sect. REGULARES (perianth regular, stamens and style fasciculate, erect.)
    N. marginata
    N. sarniensis (also *N. corusca*, *N. venusta*)

2. Sect. DISTORTAE (perianth distorted (zygomorphic), stamens and style declinate).
    N. flexuosa   *N. humilis*
    N. pulchella   *N. laticoma* (as *N. lucida*).
    N. undulata

After Baker 1896

1. Scape slender, style and stamens erect.
    N. sarniensis (incl. *N. moorei*, *N. curvifolia*).

2. Scape slender, stamens and style declinate, filaments without appendages.
    N. flexuosa   *N. humilis*
    N. angustifolia   *N. undulata*
    N. filifolia   *N. pudica*
    N. brachystemon

3. Scape slender, stamens and style declinate, filaments with appendages.
    N. appendiculata   *N. pancratioides*

4. Scape short, stout, style and stamens erect or declinate.
    N. laticoma (as *N. lucida*) *N. duparquetiana*
    N. marginata

The third classification, that of Traub (1967), is basically the same as Baker's with an altered sequence of the groups which are treated as sections (table 5). Traub's first section, *Laticomae*, includes *N. duparquentiana* and *N. laticoma* as well as *N. marginata* and this is inconsistent with the cytological findings. In Traub's treatment, *N. laticoma* is divided into several subspecies, amongst which are ssp *krigei* and ssp. *huttonii*. While the cytological data would support the close relationship of *N. laticoma* and *N. huttonii*, with satellites on a short chromosome, *N. krigei* does not appear to fit within the group. Not only is the cytological evidence at odds with the treatment, but at the morphological level too, some doubt is raised, for *N. krigei* does not have the short thick peduncle of *N. laticoma* and *N. huttonii*.

TABLE 5

Classification of *Nerine* after Traub (1967). The number of species placed in each section is given, but only those studied in the present paper are listed.

Sect. LATICOMAE peduncle short, stout, stamens and style erect or declinate.
  N. marginata   *N. duparquetiana*
  N. laticoma (incl. *N. krigei* and *N. huttonii*, the latter two as subspecies).

                                                                        3 sp.

Sect. NERINE peduncle slender, stamens and style erect.
  N. sarniensis

                                                                        1 sp.

Sect. BOWDENII peduncle slender, stamens and style declinate, filaments without appendages.
  N. flexuosa   *N. humilis*
  N. undulata   *N. bowdenii*
  N. alta   *N. filifolia*
  N. angustifolia

                                                                        18 sp.

Sect. APPENDICULATAE peduncle slender, stamens and style declinate, filaments with appendages.
  N. masonorum
  N. hesseoides

                                                                        8 sp.

Interspecific relationships in *Nerine*.

It is beyond the scope of this paper to comment on the validity or otherwise of various species of *Nerine*. It is of course likely that those species with very alike karyotypes are closely allied. Where morphological evidence also reveals similarity, a close relationship can be safely assumed. Small differences in karyotype do not exclude the possibility of close relationship or even conspecificity but the morphological data are, in the author's opinion, more meaningful. It would thus not be correct to base any opinion of species validity on the cytological evidence alone.

Conclusions on inter-relationships can still however be drawn from the karyotypes. It is very likely that the species of *Nerine* with the satellite on a small chromosome are allied and may even be subspecies of a large complex, as Traub's (1967) treatment of section *Laticomae* suggests.

In those species with the satellite on chromosome 6, the categories presented in table 2 represent groups of species usually treated as close allies. Thus those species in group 1 (ii), *N. bowdenii*, *N. alta* and *N. undulata* are placed consecutively in Traub's treatment. *N. krigei* may be allied to this group but it quite clearly is misplaced in the section *Laticomae* where Traub regarded it as a subspecies of *N. laticoma*.

Nerine angustifolia, *N. gibsonii* and *N. platypetala* would appear to be close allies, and this grouping is substantiated by the morphological evidence. The three species are very similar and were for some time regarded as a single entity. The cytological features would certainly not preclude this possibility.

The conclusion of Gouws (1971) that differences in karyotype between *N. angustifolia* and *N. platypetala* were evidence of the validity of these two species, cannot be supported. Gouws described a satellite in *N. platypetala* but did not observe one in *N. angustifolia* and the presence of the satellite in one and the absence in the other species was one of the primary reasons for his conclusion. As satellites were found in both species by the present author (fig. 1, fig. 5), the cytological evidence is not relevant to arguments on the validity of the species in question.

In group 1 (iii) *N. flexuosa* and *N. humilis* are undoubtedly closely allied, and morphological distinctions seem primarily those of size. *N. sarniensis* however, with a similar karyotype to the two former species is a very distinct entity from the morphological point of view.

The three species forming category (iv) do not appear to comprise a natural assemblage. Two of these, *N. hesseoides* and *N. masonorum* have appendages on the filaments and though the karyotypes are fairly similar, (fig. 4: A, B) the satellite chromosomes are different. *N. filifolia* on the other hand has a satellite chromosome similar to that of *N. masonorum* but in this case the remainder of the chromosomes are rather dissimilar. The general appearance of the karyotype of *N. filifolia* is reminiscent of *N. angustifolia* (fig. 1) and these two species may be closely allied.

The taxonomic position of *Brunsvigia marginata*.

The genus *Brunsvigia* was included in this study primarily because of the ambiguous position of *B. marginata*. This species has, since its description by Jacquin as a species of *Amaryllis*, been treated as *Brunsvigia* by Aiton and as *Nerine* by several authors. The situation was described by R. A. Dyer (1950–51) who, although treating the species as a *Nerine*, suggested that cytological study might prove rewarding.

The cytological evidence has indeed been helpful. The similarity of karyotype of *B. marginata* and the two other species of this genus which were examined (fig. 2: A, B, C), must be regarded as evidence of a close relationship. The less strong resemblance between the karyotypes of *B. marginata* and *N. sarniensis* has already been noted. The cytological evidence cannot therefore be regarded as conclusive and must be used in conjunction with the morphology.

An analysis of the morphological features of *Nerine* and *Brunsvigia* set out below, when taken together with the cytological data must, in the author's opinion, vindicate the treatment of *B. marginata* followed in this paper.

The bulbs of *Nerine* and *Brunsvigia* are similar in structure, although those of *Nerine* are usually much smaller. The flower of *Nerine* is either declinate with irregularly arranged petals or regular, with erect stamens, while the peduncle is either slender or stout. The fruits are poorly developed, depressed capsules

containing one or two fleshy seeds per locule, and the fruit wall, which is of a membranous texture, is usually split by pressure before the seeds are even fully developed.

The flowers of *Brunsvigia* are also declinate, or occasionally more or less regular and the petals are often joined at the base to form a tube. The peduncle is always comparatively thick while the fruit is an inflated, turbinate, three-winged capsule, often containing several seeds, the latter also being fleshy as in *Nerine*. *Brunsvigia* is peculiar in the way the inflorescence develops after flowering: the pedicels elongate and twist round until the umbel is quite spherical. Part of the peduncle is reputed to decay and the whole structure then detached, can be blown about by the wind during which time the seeds are shed. While the detachment of the inflorescence of *Brunsvigia* does not always occur, the fruits and the structure of the inflorescence in the fruiting stage are unmistakeable.

Brunsvigia marginata has the same fruit and exhibits the post fertilisation development of the umbel of a typical *Brunsvigia*. The leaves, which have not previously been mentioned, are large and broad and are prostrate. This type of leaf is unknown in *Nerine* but is found in several species of *Brunsvigia*. In fact the only resemblance which *B. marginata* bears to *Nerine* is the similarity of its flowers to *N. sarniensis*. Even here, the resemblance is more superficial than real, for the flowers of *B. marginata* have a well developed perianth tube while this feature is lacking in *N. sarniensis* and indeed in most other species of *Nerine*.

Thus to include *B. marginata* in *Nerine* would be to expand the limits of this genus and consistent treatment would compel inclusion of the genus *Brunsvigia* in *Nerine*. This treatment would be quite unsatisfactory and is also unnecessary. If *B. marginata* is included in *Brunsvigia*, then this genus and *Nerine* are easily delimited by differences in ovary, fruit and development of the umbel after fertilisation.

The resemblance of the karyotypes of *Brunsvigia* studied here to *N. sarniensis* may be fortuitous, but more likely, this indicates a close connection between *Nerine* and *Brunsvigia* through *N. sarniensis*, itself perhaps the least specialised of the Nerines.

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TYPES OF ECKLON'S 'TOPOGRAPHISCHES VERZEICHNISS' IN THE SWEDISH MUSEUM OF NATURAL HISTORY IN STOCKHOLM

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Abstract

C. F. Ecklon's 'Topographisches Verzeichniss', published in 1827, is a list of South African petaloid monocots, many of which were grown in the 1820's by Ecklon in a botanical garden on the northern slopes of Table Mountain near Cape Town. Herbarium specimens associated with this publication are located in the Swedish Museum of Natural History in Stockholm (S). The majority of Ecklon's new names are *nomina nuda*. An annotated list of these is provided. About 44 species may be regarded as validly published. No less than 32 of these are typified by specimens in Stockholm. Some nomenclatural changes result. Thus *Romulea parviflora* Eckl. has priority over *R. obscura* Klatt, and *Ixia lutea* Eckl. takes precedence over *I. conferta* Foster. A new combination is made, viz. *Ixia lutea* Eckl. var. *ovata* (Andr.) B. Nord. (syn. *I. conferta* Foster var. *conferta*).

Uittreksel

TIPES VAN ECKLON SE ,TOPOGRAPHISCHES VERZEICHNISS' IN DIE SWEEDSE NATUURKUNDIGE MUSEUM IN STOCKHOLM.
C. F. Ecklon se ,Topographisches Verzeichniss' in 1827 gepubliseer is 'n lys van Suid-Afrikaanse petaloïde eensaadlobbiges, waarvan hy heelwat in 1820 in 'n botaniese tuin teen die Noordelike hange van Tafelberg gekweek het. Herbarium eksemplare wat met hierdie publikasie verbind was word in die Sweedse Natuurkundige Museum in Stockholm (S) gevind. Die meerderheid van Ecklon se nuwe name is *nomina nuda*. 'n Geannoteerde lys van hierdie name word voorsien. Ongeveer 44 soorte word as wettig gepubliseerd beskou en nie minder as 32 van hierdie soorte word deur eksemplare in Stockholm verteenwoordig. Sommige nomenklatuur veranderings word gedoen. So geniet *Romulea parviflora* Eckl. prioriteit oor *R. obscura* Klatt en *Ixia lutea* Eckl. bo *I. conferta* Foster. 'n Nuwe kombinasie word gemaak: *Ixia lutea* Eckl. var. *ovata* (Andr.) B. Nord. (Syn I. *conferta* Foster var. *conferta*).

Introduction

Christian Frederik (or Friedrich) Ecklon (1795–1868) is justly famed for his extensive plant collections in South Africa. Ecklon, his friend C. L. P. Zeyher and J. F. Drège made up "the lynx-eyed trio" in MacOwan's exposé of botanical collectors at the Cape (MacOwan, 1887).

Ecklon did not publish much, apart from his joint publications with Zeyher (Ecklon & Zeyher, 1834–37). However, the intention of the present paper is to draw attention to his publication entitled 'Topographisches Verzeichniss der Pflanzensammlung von C. F. Ecklon'. This rare and somewhat overlooked

booklet was printed in Esslingen in 1827. It contains a list of altogether 475 South African species of "Coronariae" and "Ensatae", i.e. petaloid mono-cotyledons (Liliaceae, Iridaceae and related families). About 165 of these species were given new names by Ecklon, who could not identify them with earlier described species. Only one species, viz. *Watsonia natalensis* Eckl., was provided with a complete description in German as well as a Latin diagnosis. The majority of Ecklon's new names are clearly nomina nuda, but in many cases he added brief remarks on flower colour etc.

About 50 of Ecklon's new names are accompanied by such descriptive notes, varying in length from laconic remarks like "Blumen gelb" for *Ixia angustifolia* Eckl. to more exhaustive descriptions like that of *Ixia lutea* Eckl. (see p. 284). Both these names were dismissed as nomina nuda by Lewis (1962). Other authors have adopted some of Ecklon's species, but there has been no consistency—not even with the same author, e.g. Baker (1878, 1896)—in the criteria for retention or rejection of the names.

In order to avoid arbitrary and inconsistent treatment of Ecklon's species, some principle should be adopted in deciding which names are validly published and which are not. One of the primary requirements for valid publication in the sense of the Code is the presence of a description or diagnosis (Art. 32). A diagnosis is defined as "a statement of that which in the opinion of its author distinguishes the taxon from others" (footnote to Art. 32).

Adopting the Code's definition of a diagnosis as a guiding principle, I have ventured to judge which of Ecklon's species should be regarded as validly published. In other words, the criterion applied has been whether the descriptive phrase clearly distinguishes the taxon from others or not. E.g., "Blumen blau" is not sufficient as a diagnosis of *Vieusseuxia Brehmii* Eckl., since this is not the only blue-flowered species of that genus. Exactly the same descriptive note is given for *V. geniculata* and *V. tabularis* (Ecklon, 1827: 12–13).

On the other hand, *Geissorhiza candida* Eckl. (op. cit.: 21) may be regarded as validly published, although it is merely placed without further description under the heading "Weisse Blumen"—being the only white-flowered species known at the time.

As a result of these considerations, 44 of Ecklon's new species may be regarded as validly published. In several cases it has been difficult to judge on the adequacy of a descriptive phrase, and I am aware that other workers may arrive at diverging opinions. The validly published species are enumerated below, with comments on typification etc.

One of the main reasons for the general disregard of Ecklon's new names has no doubt been the absence of type specimens. This obstacle to an understanding of Ecklon's taxa can now be largely removed. In the herbarium of the Swedish Museum of Natural History, Stockholm (S), I have found rich material associ-

ated with Ecklon's publication. As a matter of fact, most of the collections enumerated by Ecklon are represented in S, and no less than 32 of the validly published new species can now be typified by holo- or lectotypes in this herbarium. These types have been photographed, and one set of copies will be deposited in the National Herbarium, Pretoria (PRE), and another set at Kew (K).

Some herbarium labels in Ecklon's handwriting are shown in Fig. 1. The abbreviations "A.d.b.G." and "E H B" occur on many labels and call for some comments. The former abbreviation frequently appears also in Ecklon's 'Verzeichniss' and stands for "Aus dem botanischen Garten". Similarly, "E H B" no doubt stands for "Ex Horto Botanico". The garden referred to belonged to Mr. J. A. Joubert, a Cape Town lawyer, who granted Ecklon the use of part of his property on the northern slopes of Table Mountain. This botanical garden of the 1820's is of interest as an early forerunner to the famous National Botanic Gardens, Kirstenbosch.

A sketch map of the botanical garden is attached to Ecklon's publication. The layout shows four main squares, each geometrically divided into 196 squares, one for each species. Three main squares were devoted to monocots, viz. the plants treated in Ecklon's book, and a few ferns. The fourth square housed various succulents, mainly stapeliads, 'mesems', and Crassulas. Between these squares lay a central area with palms, cycads, Strelitzias and Euphorbias. The garden was surrounded by hedges of oak and, in parts, Hydrangeas. It may be estimated that this botanical garden contained about 1 000 species of indigenous South African plants.

Apart from plants brought into cultivation, Ecklon also enumerated spontaneous collections, mainly made by himself in the southwestern Cape. Other collectors mentioned are Beil, C. H. Bergius, Brehm, Buchenröder, Fraenkel, Pallas, Mund, Ludwig, and Zeyher. C. H. Bergius must not be confused with the Swede, J. P. Bergius, who wrote on Cape plants, but never visited South Africa. Carolus Henricus (Karl Heinrich) Bergius was a German medical student, who collected at the Cape in the 1810's and died prematurely there in 1818.

For the sake of completeness it should be mentioned, that a few of the plants in Ecklon's 'Verzeichniss' had been grown in other contemporaneous Cape Town gardens, viz. those of Ludwig, Villet and J. J. B. Smuts.

ECKLON'S VALIDLY PUBLISHED SPECIES AND THEIR TYPIFICATION

Gethyllis rosea Eckl. (p. 4)

Descr.: "Die Blumen sind rosenroth und die ganze Pflanze viel kleiner als die übrigen".

Orig. coll. in S: "Am Fusse des Baviansberges 2te Höhe bei Gnadenthal. Nov. 1825" (Holotype).
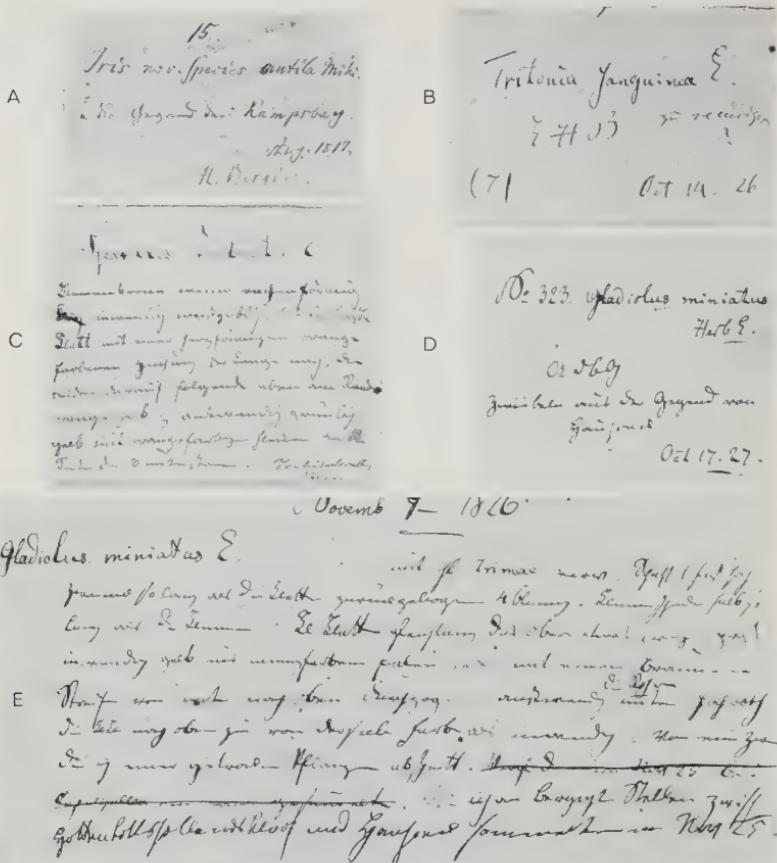
FIG. 1.

Labels and annotations from the herbarium of the Museum of Natural History, Stockholm, showing the handwritings of C. H. Bergius (A) and C. F. Ecklon (B—E). The designations "E H B" and "A d b G" refer to the garden of Mr. J. A. Joubert, where Ecklon grew his plants. See further in the text.

A: From original collection of *Vieusseuxia mutila* C. H. Bergius ex Eckl.

B: From holotype of *Tritonia sanguinea* Eckl.

C: From sheet of "*Sparaxis Joubertii* Eckl.", a manuscript name, which has caused some later confusion. It was collected by Miss H. Joubert in Zoetendaalsvalei in the old District of Caledon (but now in Bredasdorp Division). When naming the plant, Ecklon perhaps rather wanted to commemorate his patron, Mr. J. A. Joubert, than the collector—hence the masculine termination of the epithet. In the lower right-hand corner the locality has been added by O. W. Sonder. This specimen is the source of later citations like *S.* "*Joubertii* Lodd.", "*Jaubertii* Lodd." and probably also "*thoubertii* Hort." (cf. Goldblatt, 1969).

D, E: From the type sheet of *Gladiolus miniatus* Eckl.

Baker in "Flora capensis" (Baker, 1896: 194) mentioned this as a form of *G. spiralis* L.f. Obviously he had not examined the type, which has leaves densely covered with bristles and in my opinion belongs to *G. villosa* L.f.

Vieusseuxia graminifolia Eckl. (p. 11)
   Descr.: "Blumenblätter graulich".
   Orig. coll. in S: "Von Groene Berg. E H B. Sept. 29.–26" (Holotype).
The laconic diagnosis is only hesitatingly accepted as sufficient for valid publication, but no other species of the genus was described as having the same peculiar flower colour.

The sheet in S bears six specimens mounted together and also the label of Zeyher no. 1068. Apparently two collections are mixed. It may be possible to sort them out on comparison with duplicates of the latter collection.

The species was by Baker (1896: 17) cited as a synonym of *Moraea polyanthos* L.f., but Goldblatt in 1971 determined the type sheet to *M. vegeta* L. (better known as *M. juncea* sensu Ker).

Vieusseuxia mutila C. H. Bergius ex Eckl. (p. 12)
   Descr.: "Blumen blassblau".
   Orig. coll. in S: (i) "In der Gegend der Kampsbay. Aug. 1817. C. H. Bergius" (cf. Fig. 1); (ii) "Zwischen Gebüsch der 2te Höhe am Löwenrücken. Sept. 8.–26"; (iii) "Am Löwenrücken 2 Höhe. August. Ded. Ecklon".
The collections (i) and (ii) are mounted together on one sheet. (iii) is perhaps the third collection mentioned in Ecklon's list, although the label is then re-written.

The correct name of the taxon seems to be *Moraea tripetala* (L.f.) Ker var. *mutila* (Licht. ex Roemer & Schultes) Baker (1896: 23; cf. also Lewis, 1950: 230), based on *Iris mutila* Licht. ex Roemer & Schultes (1817).

Vieusseuxia pulchra Eckl. (p. 13)
   Descr.: "Blumen dunkler blau als die vorige" (i.e. *V. setacea* (Thunb.) Eckl.).
   Orig. coll. in S: "Hottentottshollandskloof am Gipfel. 4te Höhe. Nov. 25" (Holotype).
Not cited by Baker in 'Flora capensis'. The type specimen belongs to *Moraea tripetala* (L.f.) Ker (det. P. Goldblatt).

(*Vieusseuxia curvata* Eckl. (p. 13)
   Descr.: "Blumen orangegelb".
   Orig. coll. in S: "Am Weinberge bei Witteboome. Sept. 15.–26" (Holotype).
Not cited in 'Flora capensis'. The specimen is very poor and perhaps insufficient for a positive identification. It seems advisable to dismiss the name as a nomen nudum.)

Moraea minor Eckl. (p. 15)

Descr.: "Mit M. aurantiaca verwandt. Blumen orangefarben, Blätter kleiner".

Orig. coll. in S: "Sandige Stellen am Weinberge auf der östlichen Seite des Tafelberges. Sept. 15.–26" (Holotype).

Not cited in 'Flora capensis'. It is possibly a species of *Homeria* (perhaps *H. collina* (Thunb.) Vent., according to P. Goldblatt).

(*Moraea similis* Eckl. (p. 15)

Descr.: "Mit M. collina verwandt. Blumen gelb".

Orig. coll. in S: "Am Weinberge auf sandigen Stellen zwischen Gebüsch. Sept. 15.–26" (Holotype).

Mounted together with two collections of "*Moraea setifolia* Eckl.", all in a difficult mixture. According to P. Goldblatt this may also belong to the genus *Homeria*. The name is best treated as a nomen nudum.)

(*Wredowia pulchra* Eckl. (p. 16)

Descr.: "Blumen am trocknen Exemplar zinnoberfarben".

Orig. coll.: Not found in S.

This new monotypic genus was characterized by Ecklon as "Uebergang von Sisyrinchium in Aristea", which is, of course, no description. If the short diagnosis is accepted as sufficient for valid publication, however, the genus is also validated (cf. Art. 42 in the Code). However, the taxon was regarded by Baker (1892: 145, 1896: 55) as not described. Nowadays it is known as the monotypic *Pillansia templemannii* (Bak.) L.Bol. In agreement with Baker, I suggest that Ecklon's name is regarded as not validly published.)

Romulea parviflora Eckl. (p. 19)

Descr.: "Blume rosenroth klein".

Orig. coll. in S: "Feuchte Stellen der 1ten Höhe auf Grün Point. Sept. 17.–24" (Holotype).

In 1968 this specimen was determined by M. de Vos as *Romulea obscura* Klatt. Ecklon's name now takes precedence, and *R. obscura* Klatt goes into synonymy.

Geissorhiza rosea Eckl. (p. 20)

Descr.: There is no description, but since this is the only species under the heading, "Rosenrothe Blumen", it may be regarded as validly published.

Orig. coll. in S: "Ex Hort. Bot. Sept. 4.–26" (Lectotype). Mounted together with two other collections.

According to Baker (1896: 71) this is a synonym of *G. hirta* (Thunb.) Ker, which is in turn a synonym of *G. inflexa* (de la Roche) Ker var. *erosa* (Salisb.) Goldblatt (1970: 298).

Geissorhiza candida Eckl. (p. 21)

Descr.: Being the only species under the heading, "Weisse Blumen", it may with some hesitation be regarded as validly published.

Orig. coll. in S: "Hottentottsholland, Zeyher" (Holotype).

This species was not cited by Baker (1896), and its identity should be further investigated. It may prove to be *G. graminifolia* Baker, which will then go into synonymy.

(*Agretta pallideflavens* Eckl. (p. 24)

Descr.: "Blumenblätter inwendig und auswendig ganz gelb, Röhre ins weissliche fallend".

Orig. coll. in S: "Agretta [flavens delet.] pallideflavens E. Ixia [inserted: pallide] flavens E. Ex Hort Bot. Sept. 29.–26".

This species is provided with a sufficient diagnosis, but it is nevertheless not validly published, since the generic name *Agretta* was not validly published.)

Ixia punicea Eckl. (p. 24)

Descr.: "Blumenblätter inwendig und auswendig hochroth, unten mit einen kleinen grünen Stern versehen".

Orig. coll. in S: "Ex hort Bot. Sept. 20.–26" (Lectotype).

Lewis (1962: 192) regarded this as a nomen nudum and determined the specimen to *I. patens* Ait. The name is validly published, however, but it becomes illegitimate because of *I. punicea* Jacq. and *I. punicea* Spreng.

Ixia pulcherrima Eckl. (p. 24)

Descr.: "Blumenblätter hochroth glänzend".

Orig. coll.: Not found in S. Ecklon cites two collections, both from the botanical garden.

Lewis (1962: 91, 92, 127) regarded this as a nomen nudum and referring to two species, viz. *I. framesii* L. Bol. and *I. campanulata* Houtt. However, she probably saw none of the original specimens, and the identity of the species remains uncertain.

Ixia coccinea Eckl. (p. 24)

Descr.: "Blumenblätter dunkelroth mit scharlachrothen Streifen durchzogen, unten mit einen kleinen grünen Stern versehen."

Orig. coll.: Not found in S. Ecklon cites a collection from the botanical garden (A.d.b.g. Sept. 20.–26), which is thus the holotype. Ecklon added that he possessed another specimen without locality, collected by Brehm. This passage was misunderstood by Lewis, who stated: "Ecklon cited Brehm as the collector" (Lewis, 1962: 179). Lewis put the species among excluded species, and thought it might be *I. campanulata* Houtt. This remains to be proved.

At any rate, the name is a later homonym of *I. coccinea* Thunb. and thus illegitimate.

Ixia lutea Eckl. (p. 24)

Descr.: "Blumenblätter inwendig gelb, unten mit einer grossen radförmigen schwarzrothen Zeichnung, auswendig 3 blassgelb und 3 gelb, in's scharlachrothe fallend, nach unten zu bläulich. Die cultivierte Pflanze 2 Fuss hoch."

Orig. coll. in S: "Ex Hort. Bot. Sept. 20.–26" (Holotype).

By Lewis (1962: 123) said to be a nomen nudum and "amost certainly" a form of *I. conferta* Foster var. *ochroleuca* (Ker) Lewis. She did not examine the type, but her supposition seems to be correct. *I. lutea* Eckl. thus takes precedence over *I. conferta* Foster. The two varieties of this species will then have to be renamed *I. lutea* Eckl. var. *lutea* (syn. *I. conferta* Foster var. *ochroleuca* (Ker) Lewis) and *I. lutea* Eckl. var. *ovata* (Andr.) B. Nord., comb. nov. (basionym: *I. capitata* var. *ovata* Andr. Bot. Rep. t. 23, 1798).

Ixia pallide-flavens Eckl. (p. 25)

Descr.: "Bl.-Bl. inwendig blassgelb unten mit einer grossen dunkelschwarzen radförmigen Zeichnung auswendig blassgelb mit scharlachfarbenen Flecken unten grünlich grau. Die cultivirte Pflanze 2 Fuss hoch."

Orig. coll. in S: "Ex Hort. Bot. Sept. 20.–26" (Holotype).

Lewis evidently accepted this species as validly published, but she regarded its identity as uncertain and listed the species among the "Species excluded" (Lewis, 1962: 180). She noted that the species had been cited as a synonym of *I. curta* Andr. and *I. polystachya* L., and that a specimen in Geneva (G), named *I. pallide-flavens* Eckl., is *I. maculata* L. The holotype in my opinion combines characters from *I. maculata* and *I. monadelpha* de la Roche and is probably a garden hybrid.

Ixia flava Eckl. (p. 25)

Descr.: "Blumen-Blätter inwendig dunkelgelb auswendig etwas heller, Röhre dunkelroth."

Orig. coll. in S: "Ex Hort Ludwigii. Oct. 8.–26" (Holotype).

A later homonym of *I. flava* Lam. (= *Romulea bulbocodioides* fide Lewis 1962: 179) and *I. flava* Hornem. The identity of the latter is uncertain, but it has been cited as a synonym of *I. maculata* L. Lewis (l.c.) dismissed *I. flava* Eckl. as a nomen nudum and of uncertain identity. However, in 1961 Lewis had determined the type in S to *I. maculata* L., obviously without realizing its nomenclatural importance as a type specimen.

Thus *I. flava* Eckl. is an illegitimate name to be added to the synonyms of *I. maculata* L.

Ixia crocea Eckl. (p. 25)

Descr.: "Blumenblätter inwendig safranfarbig, unten mit einer grossen braunen radförmigen Zeichnung, auswendig safranfarbig, unten grünlich braun. Die ganze Pflanze 1 Fuss hoch."

Orig. coll. in S: "Ex Hort. Bot. Sept. 20.–26" (Holotype). Mounted together with two other collections by Ecklon, also named *I. crocea* by him (both from Oct. 1827). It may be difficult to sort out the original specimen from this mixture.

This name was overlooked by Lewis (1962) but Baker (1896: 8) mentioned it as a synonym of *I. maculata* L. It is antedated by *I. crocea* Thunb., which is in its turn a synonym of *Romulea triflora* (Burm.f.) N.E.Br. (fide Lewis 1962: 187).

Ixia vitellina Eckl. (p. 25)

Descr.: "Blumenblätter inwendig eiergelb, beinahe safrangelb wie I. crocea, nur etwas kleiner, unten mit einer schwarzbräunlichen, radförmigen Zeichnung, in der Mitte ein kleiner grünlich-gelber Stern, auswendig safranfarbig mit scharlachfarbenen Flecken, unten grünlich-grau. Etwas höher als I. crocea mit welcher sie am meisten Aehnlichkeit hat."

Orig. coll.: Not found in S.

By Lewis (1962: 195) in her index said to be = *I. maculata* L. but not cited among the synonyms of the latter in the text. Lewis evidently saw no type specimen, only a specimen in Geneva (G) named *I. vitellina* Eckl.

Ixia ochracea Eckl. (p. 25)

Descr.: "Blumenblätter ocherfarbengelb, inwendig mit schwarzen Flecken".

Orig. coll. in S: "Ex Hort. Bot. Sept. 10.–26" (Holotype).

Lewis (1962: 180, 191) regarded this as a nomen nudum and did not comment upon its identity. The original collection is mounted together with another specimen of unknown origin.

Ixia cana Eckl. (p. 26)

Descr.: "Blumenblätter inwendig blassgrau, unten mit einer grossen violetten radförmigen Zeichnung versehen, auswendig blassgrau, nach unten zu etwas grünlich."

Orig. coll. in S: "Ex Hort. Bot. Sept. 29. (sic!)–26" (Lectotype; Ecklon also mentions a spontaneous collection in Brehm's herbarium).

Lewis regarded this as a hybrid with *I. viridiflora* as one of the parents. She based this opinion on some specimens distributed as *I. cana* Eckl. by Ecklon. The type itself, however, was by Lewis in 1960 determined to *I. viridiflora*. Nevertheless this is also very likely a hybrid. The original material is

mounted together with one or two other specimens also named *I. cana* by Ecklon and perhaps descended from the same bulbs in the botanical garden.

Ixia alboflavens Eckl. (p. 27)

Descr.: "Blumenblätter inwendig gelbgrünlich-weiss, unten mit einer grossen schwarzbraunen, am Rande gelblichen radförmigen Zeichnung versehen, auswendig unten braun."

Orig. coll.: Not found in S.

Judging from other specimens distributed under this name, Lewis regarded this as *Ixia conferta* Foster var. *ochroleuca* (Ker) Lewis (cf. under *I. lutea* Eckl. above), and she took it to be a nomen nudum (Lewis 1962: 121, 185). Until a type specimen comes to light, *I. alboflavens* Eckl. may be cited with a question mark as a synonym of *I. lutea* Eckl.

Ixia alba Eckl. (p. 27)

Descr.: "Blumenblätter inwendig ganz weiss ohne Stern und Zeichnung".

Orig. coll. in S: "E H B. Oct. 8.–26" (Holotype). Mounted together with Ecklon & Zeyher 70.10., similarly named. Possibly the original specimens can be sorted out after a careful comparison with duplicates of the latter collection.

Lewis (1962: 96) regarded *I. alba* Eckl. as a nomen nudum and stated, that "Ecklon and Zeyher applied it to two different species". The two species concerned are *I. orientalis* L.Bol. and *I. odorata* Ker var. *hesperanthoides* Lewis. However, the name is clearly unambiguous, and the holotype was in 1961 by Lewis determined as *I. orientalis*. At any rate Ecklon's name is illegitimate because of *I. alba* L. (= *Gladiolus* sp.).

Sparaxis meleagris Eckl. (p. 27)

Descr.: "Blumenblätter bluthroth ins hochrothe fallend mit federartigen schwarzen Flecken geziert, inwendig unten gelb, auswendig unten etwas blässer".

Orig. coll.: Not found in S.

This species was not mentioned in Goldblatt's revision (1969). It is possibly a form of *S. grandiflora* (de la Roche) Ker.

Sparaxis violacea Eckl. (p. 27)

Descr.: "Blumen inwendig rothblau (veilchenfarbig) glänzend in der Mitte mit herzförmigen weissen Flecken bezeichnet, aussen von derselben Farbe nur 3 Blätter etwas heller".

Orig. coll.: Not found in S.

The species was accepted by Klatt, who described it more fully and also provided a Latin diagnosis (Klatt, 1882: 389). In the recent revision by Goldblatt (1969) this is *S. grandiflora* (de la Roche) Ker subsp. *violacea* (Eckl.) Goldblatt. The latter author designated the sheet Ecklon & Zeyher 114 in SAM as "lecto-

type". This is inadmissible, since in the original description only two collections from Ecklon's garden are cited. If no original material comes to light, the collection chosen by Goldblatt may be regarded as a neotype.

Sparaxis cana Eckl. (p. 28)

Descr.: "Blumenkrone inwendig unten mit einem gelblichen Sternchen und violetten Ecken im weissen Felde, oben blassgrau, nach der Mitte zu ins violette fallend, von den äussern Blumenblättern 3 aschgrau, 3 etwas blässer".

Orig. coll. in S: "Ex Hort. Ludwigii. Sept. 30.–26" (Holotype). In the text said to be collected in 1816, which is obviously a misprint for 1826.

Goldblatt did not mention this species in his revision (1969), but after examing the type he refers it to *S. grandiflora* (de la Roche) Ker subsp. *violacea* (Eckl.) Goldblatt. The colour and markings of the flower are very variable in the latter taxon.

Sparaxis lutea Eckl. (p. 28)

Descr.: "Nicht so hoch als die vorige[1], die Blumen sind beim Aufblühen gelb und bleiben gelb nach dem Trocknen".

Orig. coll. in S: "Ex Hort. Ludwigii. Sept. 20.–26" (Holotype).

This was with some hesitation cited by Goldblatt (1969: 245) in the synonymy of *S. grandiflora* (de la Roche) Ker subsp. *acutiloba* Goldblatt. He did not adopt Ecklon's name, because of the inadequate description and the apparent absence of type material.

The holotype deviates from typical *S. grandiflora* subsp. *acutiloba* by the branching, bulbil-bearing stem. In these respects the plant resembles *S. bulbifera* (L.) Ker, which, however, never has yellow flowers (Goldblatt, 1969: 239). After examining the type specimen, Goldblatt maintains his view, that *S. lutea* is a synonym of *S. grandiflora* subsp. *acutiloba*. The atypical appearance of the plant may be due to effects of cultivation.

Tritonia sanguinea Eckl. (p. 29)

Descr.: "Blumenblätter dunkelrosenroth ins blutrothe fallend, kleiner als Tr. fenestrata unten am Rande jedes Blumenblatts stark durchscheinend".

Orig. coll. in S: "E H B. Oct. 14.–26" (later added: "zu securigera ?") (Holotype).

Baker (1892: 190; 1896: 119) regarded this and the following species as colour varieties of *T. crocata* (L.) Ker.

Tritonia coccinea Eckl. (p. 29)

Descr.: "Blumenblätter orangefarben ins scharlachfarbene fallend, nur unten mit gelbem Stern und violetter, herzförmiger Zeichnung, der Rand wenig

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[1]Refers to *S. albiflora* Eckl., a superfluous name for *S. bulbifera* (L.) Ker.

durchsichtig, aussen orangefarben ins scharlachbläuliche fallend und unten weisslich. Mit Tr. aurantiaca am nächsten verwandt".

Orig. coll.: Not found in S.

Tritonia aurantiaca Eckl. (p. 29)

Descr.: "Blume safranfarben etwas dunkler als Tr. crocata, unten weniger durchsichtig und jedes einzelne Blumenblatt, unten mit einer herzförmigen orangefarbenen Zeichnung versehen".

Orig. coll.: Not found in S.

(*Freesea miniato-lateritia* Eckl., p. 30, is provided with a fairly lengthy description, but is nevertheless not validly published, since it was subordinate to a genus not validly published, viz. "Freesea Eckl."; cf. Art. 43 of the Code.)

(*Babiana angustifolia* Eckl., p. 31, is a nomen nudum. It is also antedated by *B. angustifolia* Sweet (syn. *B. pulchra* (Salisb.) Lewis). The correct name of this taxon is *B. nana* (Andr.) Spreng. var. *maculata* (Klatt) B. Nord. See further Nordenstam, 1970: 442.)

Babiana lilacina Eckl. (p. 31)

Descr.: "Blumenblätter gleich lang, inwendig lilafarben und unten mit einem blauen Stern bezeichnet, auswendig etwas heller und nach unten zu ins Blaue fallend".

Orig. coll.: Not found in S.

Lewis (1959: 53) cited this as a synonym of *B. plicata* Ker. She did not see the type, only other specimens named *B. lilacina* by Ecklon, but her interpretation seems quite acceptable.

Babiana stellata Eckl. (p. 32)

Descr.: "Blumenblätter lilafarben und regenbogenfarbig gesternt".

Orig. coll. in S: "Ex Hort. Bot. Sept. 4.–26" (Holotype).

The specimen is difficult to determine; perhaps it is *B. angustifolia* Sweet (syn. *B. pulchra* (Salisb.) Lewis).

Babiana rosea Eckl. (p. 32)

Descr.: "Blumenblätter inwendig rosenroth, die äusseren blässer mit einem weissen Striche durchzogen. Nach dem Trocknen geht die schöne rosenrothe Farbe ins Blaue über."

Orig. coll. in S: "Ex Hort Bot. Sept. 20.–26" (Holotype).

Lewis (1959) dismissed the species as a nomen nudum, and having seen no original specimens, she guessed that it might be *B. villosa* (Ait.) Ker var. *grandis*. Two collections are mixed on the sheet in S, but Lewis' suggestion appears plausible.

Babiana punicea Eckl. (p. 32)

Descr.: "Blumenblätter inwendig hochroth, die äusseren von derselben Farbe und 3 derselben mit einem dünnen ins gelbliche fallende Striche durchzogen."

Orig. coll. in S: "No. 2 am Sept. 10.–26. Ex Hort Bot. Sept. 20.–26" (Holotype).

Lewis in her revision (1959) listed the name in the synonymy of *B. villosa* (Ait.) Ker. without having seen the type. Her treatment is confirmed by a study of the type.

Babiana flavocaesia Eckl. (p. 32)

Descr.: "Blumenblätter inwendig gelblich-blaulich, unten dunkler gelb, auswendig 3 blasblau und 3 gelblich mit einem blassblauen Streifen durchzogen. Blätter breit."

Orig. coll. in S: "Aus der Gegend um Stellenbosch. Sept. 20.–26" (Holotype).

Lewis did not see any specimens named *B. flavocaesia* Eckl. but nevertheless concluded that the taxon referred to was *B. stricta* (Ait.) Ker var. *sulphurea* (Jacq.) Baker. Her supposition can now be confirmed.

Babiana caesia Eckl. (p. 32)

Descr.: "Blumenblätter gleich lang, inwendig weiss und unten mit blaulich rothen Flecken, auswendig hellblau, unten etwas dunkler, drei Blumenblätter eben ins gelbliche fallend. Blätter schmal und stark zugespitzt."

Orig. coll.: Not found in S.

Lewis (1959), without having traced the type, supposed this to be *B. stricta* (Ait.) Ker var. *erectifolia* (Lewis) Lewis.

Babiana atrocyanea Eckl. (p. 33)

Descr.: "Blume blau mit schwarzem Stern."

Orig. coll. in S: "Ex Hort Bot. Sept. 4.–26" (Holotype).

From the description Lewis (op. cit.) judged that this would be "*B. pulchra* (Salisb.) Lewis", the correct name of which is *B. angustifolia* Sweet (cf. Nordenstam, 1970: 440). The specimen is difficult to determine, but Lewis' suggestion seems plausible.

Babiana atrodeltoidea Eckl. (p. 33)

Descr.: "Blumenblätter gleich lang, inwendig schmaltblau, unten etwas heller und mit einem dunklern sammetfarbenen Sterne gezeichnet, auswendig schmaltblau nach unten zu ins rötliche fallend. Blätter schmal."

Orig. coll. in S: "Ex Hort Bot. Sept. 20.–26" (Lectotype; the other specimen cited by Ecklon is not present in S).

Lewis (op. cit.) guessed that also this name should be a synonym of *B.* "*pulchra*", i.e. *B. angustifolia* Sweet. and I can now confirm her supposition.

Babiana reflexa Eckl. (p. 33)
   Descr.: "Eine ausgezeichnete Art. Blumen blau, spiralförmig um den zurückgebogenen Blumenstiel gewunden."
   Orig. coll. in S: (i) "Flor Afric austral. aus meinem Garten. Sept. 25." (Lectotype). (ii) "E H B. Oct. 14.–26" (Paratype).
   This is a synonym of *B. secunda* (Thunb.) Ker and a later homonym of *B. reflexa* (Licht.) Ker.

Antholyza ludwigii Eckl. (p. 34)
   Descr.: "Durch einen niedrigern Habitus, hervorstehende, blaulichschwarze Stamina und vorzüglich durch die verschiedene Blühtezeit von der vorigen verschieden."
   Orig. coll. in S: "Zwischen A. praealta und A. nervosa. Aus Herrn Ludwigs Garten, der Standort ist nicht bekannt. Dezember 17., 1826" (Holotype).
   Baker did not cite this in 'Flora capensis', but he mentioned a *Watsonia Ludwigii* Eckl. MS. as a synonym of *W. meriana* var. *roseo-alba* (Jacq.) Ker (Baker, 1896: 101). The type specimen is mounted together with Zeyher 4023, named *Watsonia Ludwigii* Eckl.

Watsonia natalensis Eckl. (p. 34)
   Descr.: "Corollis infundibuliformibus cernuis, laciniis ovatis mucronatis subringentibus, spathis corollae tubo brevioribus, foliis ensiformibus multinerviis." This is followed by a lengthy description, which it is not necessary to repeat in full here.
   Orig. coll. in S: "Ex Horto quoque (von Farewells Kolonie an der Küste Natals). November 1826" (Holotype).—See Fig. 2.
   This species is now known as *Gladiolus natalensis* (Eckl.) Reinw.

Gladiolus thunbergii Eckl. (p. 37)
   A nomen novum for *G. communis* Thunb. non L. and thus validly published. The identity of Ecklon's specimens so named is of no importance for the application of the name. The material belongs to *G. ornatus* Klatt (det. G. J. Lewis).

Gladiolus pilosus Eckl. (p. 38)
   Descr.: "Blätter linienförmig, unten haarig, Blumenblätter wenig zugespitzt hellrosenroth, die untern etwas heller mit dunklern Flecken".
   Orig. coll. in S: "Zwischen Gebüsch in der Fläche bei Weinberg. August" (Lectotype).

TYPUS.

Fɪɢ. 2.
Holotype of *Watsonia natalensis* Eckl., now known as *Gladiolus natalensis* (Eckl.) Reinw., in the Museum of Natural History, Stockholm.

The label is probably of later date than the publication of Ecklon's "Verzeichniss". It is possible, however, that the specimen represents a part of the original collection although with a re-written label, and I choose this specimen as lectotype.

This species is also known as *G. villosus* Ker, but the correct name is *G. punctulatus* Schrank (Lewis, 1966: 291).

Gladiolus pendulus Mund ex Eckl. (p. 38)

Descr.: "Eine ausgezeichnete Art mit langen fadenförmigen, etwas spiralförmig gewundenen Blumenstielen und rothblaulichen Blumen".

Orig. coll. in S: "Zwiebeln aus der Gegend um Georgestown. A.d.b.G. Januar 7. 27" (Lectotype).

In the description the date of collecting is said to be Dec. 30, 1826. Either this is a mistake, or Ecklon made a second collection one week later in the garden, and for some reason the latter collection is not cited in the description. At any rate Ecklon must have had the specimen preserved in S available, when he wrote his manuscript, and it may be designated as lectotype.

The species is obviously a *Dierama*, no doubt *D. pendula* (L.f.) Baker.

Gladiolus versicolor Eckl. (p. 39)

Descr.: "Mit Gl. tristis verwandt. Die drei obern Blumenblätter haben inwendig schwarze Flecken und alle Blumenbl. sind auswendig schwarz gefleckt."

Orig. coll.: Ecklon mentions two collections from the botanical garden, but none of these was found in S.

The name is a later homonym of *G. versicolor* Andr.

Gladiolus similis Eckl. (p. 40)

Descr.: "Durch kleinere minder gefleckte blassere Blumen van Gl. hirsutus verschieden."

Orig. coll. in S: "Ex Hort. Ludwigii. Sept. 5–26" (Lectotype; the other specimen mentioned by Ecklon was not found in S).

According to an annotation by Lewis in 1965 the type specimen is *G. caryophyllaceus* (Burm.f.) Poir.

Gladiolus miniatus Eckl. (p. 40)

Descr.: "Schaft 1 Fuss hoch zweimal so lang als die Blätter zurückgebogen 4-blumig. Blumenscheiden halb so lang als die Blumen. Blumenbl. gleichlang, das obere etwas weniger grösser, inwendig gelb ins mennigfarbene fallend, jedes mit einem braunen Streifen von unten nach oben durchzogen; auswendig die Röhre unten hochroth, die Blumenbl. nach oben zu von derselben Farbe als inwendig."

Orig. coll. in S: "Von einem Zwiebel den ich von einer getrockneten Pflanze abschnitt, die ich an bergigten Stellen zwischen Hottentottshollandskloof und Hauhoek sammelte in Nov. 25". The labels (Fig. 1) match the text of the published description. On the sheet are mounted three specimens. Probably the right hand specimen is intended, and I designate this as lectotype. The two left hand specimens probably belong to another label, according to which they were collected in the garden on Oct. 17, 1827, thus after the publication of Ecklon's "Verzeichniss".

List of Ecklon's *NOMINA NUDA*

As mentioned in the introduction, the majority of Ecklon's names are not validly published. However, several of them have been cited by later authors, and a few have even been treated as validly published. A list of these names and, wherever possible, their true identity, may therefore be useful. The nomina nuda are either names published without a diagnosis, or they are provided with a brief descriptive remark, which is regarded as insufficient to differentiate the species from its congeners. The list also includes species, which are invalid, because they were published under generic names, not validly published. An asterisk denotes that original material, i.e. collection cited in Ecklon's publication, is preserved in the Museum of Natural History, Stockholm (S). Some colleagues have been most helpful in assigning correct names to these specimens. I especially want to thank Dr. Peter Goldblatt, Cape Town, and Miss Mary Thompson, Stellenbosch. Their names will be abbreviated below as P.G. and M.T., respectively.

Drimia humilis C. H. Bergius ex Eckl. (p. 2)

Eriospermum spirale C. H. Bergius ex Eckl. (p. 2) (Later validly published as *E. spirale* C. H. Bergius ex Schultes in Roemer & Schultes, 1830)

Forbesia Eckl. (p. 4)

F. plicata (L.) Eckl. (p. 4) (Based on *Hypoxis plicata* L., but combination not validly published; cf. Art. 43 in the Code)

*F. angustifolia Eckl. (p. 5) = *Curculigo plicata* (L.f.) Ait. (syn. *Empodium plicatum* (L.f.) Salisb.; conf. M.T.)

*Ornithogalum palustre Eckl. (p. 6) = *O. thyrsoides* Jacq. (det. M.T.)

*Androcymbium littorale Eckl. (p. 7)

*A. cuculatum (sic!) Eckl. (p. 7) (Ecklon lists two further species of this genus, viz. *eucomoides* and *leucanthum*. Unfortunately, all four collections are mounted together on one sheet. It seems impossible to connect labels and specimens, and the identity of the two nomina nuda remains obscure.)

*Brunsvigia albiflora Eckl. (p. 7) = *Crinum latifolium* L. (The specimen looks more like this East Asiatic species than any of the Cape Crinums. It is most likely a garden plant.)

*Hypoxis geniculata Eckl. (p. 9) = *Spiloxene capensis* (L.) Garside

**H. acuminata* Eckl. (p. 9) = *Spiloxene capensis* (L.) Garside

**H. laxa* Eckl. (p. 9) = *Spiloxene capensis* (L.) Garside

**H. flavescens* Eckl. (p. 9) = *Spiloxene capensis* (L.) Garside

**H. longifolia* Eckl. (p. 9) = *Spiloxene capensis* (L.) Garside (conf. M.T.)

**H. aurea* Eckl. (p. 10) = *Spiloxene capensis* (L.) Garside (conf. M.T.)

**H. tenuifolia* Eckl. (p. 10) = *Spiloxene capensis* (L.) Garside

**H. juncea* Eckl. (p. 10) = *Spiloxene capensis* (L.) Garside (conf. M.T.)

**H. luzulaefolia* Eckl. (p. 10) = *Spiloxene serrata* (Thunb.) Garside (conf. M.T.)
(On one sheet mixed with *S. capensis*)

**H. flavopetala* Eckl. (p. 10) = probably a small, unspotted form of *Spiloxene capensis* (L.) Garside (det. M.T.)

**H. filifolia* Eckl. (p. 10) (Ecklon's collection from Table Mountain is mounted together with two collections from Caledon Division. No less than four species are represented on the sheet, however, and the identity of Ecklon's name is uncertain. The four species are *Spiloxene capensis, declinata, schlechteri* and *serrata*. All but *S. declinata* occur on the Peninsula.)

**H. tabularis* Eckl. (p. 10) = *Spiloxene schlechteri* (Bol.) Garside (det. M.T.)

H. minor Eckl. (p. 10)

H. spathacea Eckl. (p. 11)

**Vieusseuxia rivularis* Eckl. (p. 11) = *Moraea vegeta* L. (det. P.G.)

**V. intermedia* Eckl. (p. 12) = *Moraea papilionacea* (L.f.) Ker (det. P.G.)

**V. nervosa* Eckl. (p. 12) = *Moraea papilionacea* (L.f.) Ker (det. P.G.)

**V. Brehmii* Eckl. (p. 12) = *Moraea gawleri* Spr. (det. P.G.)

**V. angustifolia* Eckl. (p. 12) = *Moraea gawleri* Spr. (det. P.G.)

**V. multifolia* Eckl. (p. 12) = *Homeria* sp. (det. P.G.)

**V. geniculata* Eckl. (p. 12) = *Moraea mira* Klatt (det. P.G.)

**V. multiflora* Eckl. (p. 12)

V. collina Eckl. (p. 12)

V. pauciflora Eckl. (p. 12)

V. gracilis Eckl. (p. 12)

**V. aurantiaca* Eckl. (p. 13) = *Moraea insolens* Goldbl. MS. (det. P.G.)

V. tabularis Eckl. (p. 13)

**V. curvata* Eckl. (p. 13) = ? (Material inadequate; cf. p. 281)

**V. grandiflora* Eckl. (p. 14) = *Moraea* cf. *angusta* (L.f.) Ker (det. P.G.)

**V. plumaria* Eckl. (p. 14) = *Moraea angusta* (L.f.) Ker (det. P.G.) (Probably this was intended as a new name, rather than a new combination of the older *Iris plumaria* Thunb. The author quotation "Eckl." is missing in the publication, but it occurs on the label to the original specimen.)

V. edulis Eckl. (p. 14)

V. longifolia Eckl. (p. 14)

V. lutea Eckl. (p. 14) = *Moraea angusta* (L.f.) Ker (det. P.G.)
 Freuchenia Eckl. (p. 14)
F. bulbifera Eckl. (p. 14)   *Moraea ramosissima* (L.f.) Druce (det. P.G.)
Moraea multiflora Eckl. (p. 14)   cf. *Homeria* sp. (det. P.G.; material inade-
  quate)
 M. setifolia Eckl. (p. 14)
M. pauciflora Eckl. (p. 14) = cf. *Homeria* sp. (det. P.G.)
M. aurantiaca Eckl. (p. 15) = *Homeria ochroleuca* Salisb. (det. P.G.)
M. similis Eckl. (p. 15) = cf. *Homeria* sp. (possibly *H. collina* (Thunb.) Vent.;
  cf. p. 282)
M. humilis Eckl. (p. 15) = *Gynandriris setifolia* (L.f.) Foster (det. P.G.)
Sisyrinchium inundatum Eckl. (p. 16) = *Cleanthe bicolor* Salisb. (det H.
  Weimarck)
S. grandiflorum Eckl. (p. 16) = *Aristea spiralis* (L.f.) Ker (det. H. Weimarck)
 Wredowia Eckl. (p. 16) = *Pillansia* L. Bol.
 W. pulchra Eckl. (p. 16) = *Pillansia templemannii* (Bak.) L.Bol. (cf. p. 282)
Aristea juncifolia Eckl. (p. 16) = *A. racemosa* Bak. var. *inflata* H. Weim.
  (det. H. Weimarck)
A. umbellata Eckl. (p. 16) = *A. schizolaena* Harv.? (det. H. Weimarck, but the
  locality is wrong for this species; the sheet bears also a specimen of *A.
  pusilla* (Thunb.) Ker)
A. diffusa Eckl. (p. 16) = *A. pauciflora* W.-Dod (det. H. Weimarck)
A. intermedia Eckl. (p. 16) = *A. dichotoma* (Thunb.) Ker (det. H. Weimarck)
 Galaxia violacea Eckl. (p. 17)
Ferraria major Eckl. (p. 18) = *F.* cf. *undulata* L. (det. P.G.)
 Romulea vulgaris Eckl. (p. 18)
 R. tabularis Eckl. (p. 18)
 R. arenaria Eckl. (p. 18)
R. zeyheri Eckl. (p. 19) = *Geissorhiza secunda* Ker (det. M. de Vos)
R. hirsuta Eckl. (p. 19) = *R. hirsuta* (Klatt) Bak. (det. M. de Vos)
 R. ramosa Eckl. (p. 19)
R. similis Eckl. (p. 19) = *R. flava* (Lam.) de Vos var. *viridiflora* (Berg.) de Vos
  (det. M. de Vos)
Geissorhiza cyanea Eckl. (p. 20) = *G. rochensis* Ker (det. P.G.)
G. nigro-montana Eckl. (p. 21) = *G. pusilla* (Andr.) Klatt (det. P.G.)
G. aurea Eckl. (p. 21) = *G.* cf. *bicolor* (Thunb.) N.E.Br. (det. P.G.)
 G. lutea Eckl. (p. 21)
G. Brehmii Eckl. (p. 21) = *G. imbricata* (de la Roche) Ker var. *brehmii* (Eckl. ex
  Klatt) Foster (det. P.G.)
G. romuleoides Eckl. (p. 21) = *G. ornithogaloides* Klatt (det. P.G.)
G. striata Eckl. (p. 21) = *G. imbricata* (de la Roche) Ker (1 specimen, mounted

together with specimens of *G. humilis* (Thunb.) Ker, leg. Sieber, Fl. Cap. Nro. 395)

G. arenaria Eckl. (p. 21)

**G. tenuis* Eckl. (p. 22) = *G. humilis* (Thunb.) Ker (det. P.G.)

**G. setifolia* Eckl. (p. 22) = *G. juncea* (Link) A. Dietr. (det. P.G.)

Weihea Eckl. (p. 22)

W. excisa (L.) Eckl., non rite publ. (p. 22)

W. elatior Eckl. (p. 22)

Hesperantha crispa Eckl. (p. 22)

H. maritima Eckl. (p. 23)

H. pallida Eckl. (p. 23)

**H. ramosa* Eckl. (p. 23) = *Geissorhiza* cf. *juncea* (Link) A. Dietr. var. *pallidiflora* (Schltr) Foster (det. P.G.)

**H. quinquangularis* Eckl. (p. 23) = *Geissorhiza inflexa* (de la Roche) Goldbl. (det. P.G.)

H. setacea Eckl. (p. 23)

Agretta Eckl. (p. 23)

A. grandiflora Eckl. (p. 23)

A. stricta Eckl. (p. 23)

A. pentandra (L.f.) Eckl., non rite publ. (p. 23)

A. crispa (L.f.) Eckl., non rite publ. (p. 24)

**A. pallideflavens* Eckl. (p. 24) = *Ixia odorata* Ker var. *hesperanthoides* Lewis (det. P.G.) (In spite of the diagnosis, the name is not validly published, being subordinate to a genus not validly published; cf. p. 283)

**Ixia palliderosea* Eckl. (p. 24) = *I. patens* Ait. (det. G. J. Lewis)

I. angustifolia Eckl. (p. 25)

I. flavescens Eckl. (p. 26)

I. flavovirens Eckl. (p. 26)

**I. caerulescens* Eckl. (p. 26) = *I. versicolor* Lewis (det. G. J. Lewis)

I. dubia Eckl. (p. 26)

**I. campanuloides* Eckl. (p. 26) = probably a hybrid of *I. viridiflora* Lam. (det. G. J. Lewis)

**I. lilacina* Eckl. (p. 27) = *I. polystachya* L. (det. G. J. Lewis)

Sparaxis luteoviolacea Eckl. (p. 27)

Tritonia dubia Eckl. (p. 30)

Freesea Eckl. (p. 30)

**F. miniatolateritia* Eckl. (p. 30) = *Ixia framesii* L. Bol. (det. P.G.) (In spite of the diagnosis this was not validly published, since the genus was not validly published. See also p. 288 and Brown, 1935:1)

F. longiflora (Ker) Eckl., non rite publ. (p. 30)

F. flava Eckl. (p. 30)

*F. secunda Eckl. (p. 30) = *Tritonia flabellifolia* (de la Roche) Lewis (det. P.G.)

F. crispa (Ker) Eckl., non rite publ. (p. 30)

*Lapeirousia azurea Eckl. (p. 31) = *L. corymbosa* (L.) Ker (det. P.G.)

Babiana angustifolia Eckl. (p. 31) = *B. nana* (Andr.) Spr. var. *maculata* (Klatt) B. Nord. (cf. p. 288 and Nordenstam, 1970: 442)

B. caerulescens Eckl. (p. 32)

*Watsonia tabularis Eckl. (p. 35) = *W. tabularis* Mathews & L. Bol. (det. P.G.)

W. iridifolia Eckl. (p. 35)

*W. merianella Eckl. (p. 36) = *W. humilis* Mill. (det. P.G.)

*W. dubia Eckl. (p. 36) = *W. dubia* Eckl. ex Klatt (det. P.G.)

W. pellucida Eckl. (p. 36)

*W. tubulosa Eckl. (p. 36) = *W. aletroides* Ker (det. P.G.)

*W. pottbergensis Eckl. (p. 36) = *W. stenosiphon* L. Bol. (det. P.G.)

W. tigrina Eckl. (p. 36)

Neuberia Eckl. (p. 37)

N. marginata (L.f.) Eckl., non rite publ. (p. 37)

N. humilis Eckl. (p. 37)

*N. longifolia Eckl. (p. 37) = a mixture of *Gladiolus kirkii* Bak. and *Watsonia* cf. *longifolia* Mathews & L. Bol. (det. G. J. Lewis). The locality is wrong for the former species, so probably only the pieces of the latter species (a few leaves) are connected with the label.

N. rosea Eckl. (p. 37)

N. pyramidalis Eckl. (p. 37)

*Gladiolus setifolius Eckl. (p. 37) = *G. gracilis* Jacq. (det. P. G. and T. T. Barnard)

*G. tabularis Eckl. (p. 38) = *G. pappei* Bak. (det. P. G. and T. T. Barnard)

*G. costatus Eckl. (p. 38) = *Engysiphon schinzii* (Bak.) Lewis (det. G. J. Lewis)

G. adenandriflorus Eckl. (p. 38)

*G. zeyheri Eckl. (p. 38) = *G. punctulatus* Schrank (det. G. J. Lewis)

*G. aghullensis Eckl. (p. 41), according to T. T. Barnard = the Agulhas form of *G. miniatus* Eckl.

*G. speciosus Eckl. (p. 41) = *G. cardinalis* Curt. (conf. P. G. and T. T. Barnard)

*G. dubius Eckl. (p. 41) = *G. blandus* Ait. (which is almost certainly a form of *G. carneus* de la Roche, fide G. J. Lewis; see also Goldblatt, 1970:311)

*Hebea bicolor Eckl. (p. 42) = *Gladiolus virescens* Thunb. (det. G. J. Lewis) (Mounted with a collection of *G. venustus* Lewis, leg. Ecklon & Zeyher)

H. zeyheri Eckl. (p. 42)

*H. ramosa Eckl. (p. 43) = *Tritoniopsis ramosa* (Eckl. ex Klatt) Lewis (det. G. J. Lewis)

Beilia Eckl. (p. 43)

*B. triticea (Thunb.) Eckl., non rite publ. (p. 43). Ecklon's material is *Thereianthus bracteolatus* (Lam.) Lewis (det. P.G.)

B. spicata (L.) Eckl., non rite publ. (p. 43)

Micranthus plantagineus Eckl. (p. 43). This has generally been regarded as a new combination of either *Ixia plantaginea* Ait. or *Gladiolus plantagineus* Pers. (see e.g. Baker, 1892: 179, 1896: 97, Lewis, 1950: 240, 1962: 192). However, there is no reference to earlier publications, and hence the name cannot be regarded as validly published.

*M. alopecuroideus Eckl. (p. 43) = *M. plantagineus* (Ait.) "Eckl." (det. P.G.)

*M. fistulosus Eckl. (p. 44) = *M. tubulosus* (Burm.f.) N.E.Br. (det. P.G.)

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————— 1830. *Ibid.* 7, 2. Stuttgart.

A NEW VARIETY OF *CYRTORCHIS PRAETERMISSA* FROM ZULU-LAND.

E. R. HARRISON

(*Palm Ridge*, *Mtubatuba*)

ABSTRACT

A new variety of *Cyrtorchis praetermissa* Summerh., *C. praetermissa* Summerh. var. *zuluensis* E. Harrison, is described.

UITTREKSEL

'N NUWE VARIËTEIT VAN *CYRTORCHIS PRAETERMISSA* VANAF SOELOE-LAND

'n Nuwe variëteit van *Cyrtorchis praetermissa* Summerh., *C. praetermissa* Summerh. var. *zuluensis* E. Harrison, word beskryf.

INTRODUCTION

During the preparation of a "*Field Guide to the Epiphytic Orchids of Southern Africa*" (Harrison, 1972), it was found that the Zululand plants, previously considered to be conspecific with the tropical *Cyrtorchis praetermissa*, differed from the tropical plants in a number of characters. These differences were considered sufficiently distinctive to merit formal taxonomic recognition. Consequently, it was decided to accord the Zululand plants varietal rank to distinguish them from the tropical material of *C. praetermissa*. This opportunity is now taken of describing and discussing the new variety.

Cyrtorchis praetermissa Summerh. in Kew Bull. **3**: 279 (1948). Type: Zambia, MWINILUNGA District, just south of Matouchi Farm, *Milne-Redhead* 3146 (K. holo.) var. **praetermissa**—Distribution:- Uganda, Tanzania, Zambia, Rhodesia, Transvaal.

Var. **zuluensis** E. Harrison, var. nov. affinis *C. praetermissa* sed plantae minioribus, foliis planis non carnulosa sed coriacea, vagina non rugulosa; calcar apice incurvata.

Type: Natal—2832 (Mtubatuba): Zululand, Hlabisa Distr., near Nyalazi R. bridge, (AB), 2/ii/1955, *Schelpe* 5216 (BOL, holo.).

The stems, 8—14 cm long and 7—9 mm in diameter carry roots 3—4 mm in diameter. The eight to twelve closely-set leaves are 7—9 cm long and 1—1,3 cm

broad; linear with rounded unequal bilobes. Usually two inflorescences 7—8 cm long are produced, each carrying twelve to fourteen flowers arranged in two ranks. The white flowers 1,5 cm across turn deep orange with age and the spur, 2,3—2,5 cm long, is curved with a hooked tip.

The chief differences between the two are the leaf characters and flower sizes. The leaves are linear and strap-shaped in the new variety whereas in *C. praetermissa* var. *praetermissa* they are leathery, deeply keeled and recurved. The flowers are slightly larger than in the typical variety, with narrower floral segments which curve back considerably with age. The spur is also slender with a pronounced tip. The aerial roots differ in colour—being grey, smudged with brown and having tips of reddish-brown.

Geographically, the two are widely separated and, although the new variety occurs in an amazing range of climate conditions, plant and flower characteristics remain constant in all localities.

In common with *C. arcuata* this new variety occurs in a range of habitats from hot, humid coastal forest to cool moist temperate forests. It also occurs in low rainfall areas which experience high summer temperatures. In all these varied localities, plants occur in large colonies; often hundreds of plants occupy a single tree in light to heavy shade. Distribution: Natal; Mtunzini, Lower Umfolozi, Hlabisa, Ubombo, Ngwavuma Districts.

THE TYPIFICATION OF *BRUNIA NODIFLORA* L.

E. Powrie

(*Bolus Herbarium, University of Cape Town.*)

Abstract

Examination of the type material of the Linnean species of Bruniaceae reveals that the type of *Brunia nodiflora* L. is not a specimen of this family at all but a twig of the gymnosperm at present known as *Widdringtonia cupressoides* (L.) Endl. This will not only cause a serious upheaval of nomenclature in the Bruniaceae unless the genus *Berzelia* Brongn. be conserved, but necessitates a new combination in *Widdringtonia*.

Uittreksel

DIE TIPE-EKSEMPLAAR VIR *BRUNIA NODIFLORA*.

Ondersoek na die tipe materiaal vir die Bruniaceae soorte deur Linneus beskryf bring aan die lig dat die tipe vir *Brunia nodiflora* L. nie 'n eksemplaar van hierdie familie is nie maar wel 'n takkie van 'n naaksaadige tans bekend as *Widdringtonia cupressoides* L. (Endl). Dit sal nie net ernstige gevolge vir die nomenklatuur van Bruniaceae tot gevolg hê nie (tensy *Berzelia* Brongn. gekonserveer word) maar sal ook nuwe kombinasies in *Widdringtonia* tot gevolg hê

Brunia nodiflora L. was proposed as the type species of the genus Brunia by Hitchcock in the proposals of British botanists submitted to the International Botanical Congress of 1930. This was more or less inevitable since Brongniart's subdivision (1826) of the Linnean genus *Brunia* left only this species of the six placed in *Brunia* by Linnaeus (1753) to typify the original genus. Linnaeus' original description of *Brunia nodiflora* was the diagnosis in the Hortus Cliffortianus (1738) which was transferred unaltered to the Species Plantarum ed. 1 (1753), adding the epithet *nodiflora*. The type specimen must, therefore, be that in the Clifford Herbarium. When this specimen, *Brunia* 1, was examined in the British Museum, it was found not to be a member of the Bruniaceae at all, but a sterile twig about 10 cm long, having the typical adpressed, decussate, cupressoid leaves of *Widdringtonia*. This matched satisfactorily with identified material of *Widdringtonia cupressoides* in the British Museum main collection. I did not have the opportunity of sectioning the leaves but from their strongly angled midribs have no doubt that they are triangular rather than elliptical in section (c.f. Marsh's leaf characters in Flora of Southern Africa I) and in any case a specimen dating back to 1738 could hardly be *Widdringtonia cedarbergensis* or *Widdringtonia schwarzii*. The same conclusion had been reached by some unknown

predecessor, who has pencilled *Widdringtonia cupressoides* on the sheet. In the Species Plantarum Linnaeus also noted illustrations in Breynius and Plukenet which are undoubtedly *Brunia nodiflora* sensu Brongniart but the diagnostic phrase *foliis quadrifariam imbricatis* is clearly based on the specimen not the illustrations, nor could it apply to any member of the Bruniaceae in which the leaves are spirally inserted and never decussate. Nor is it possible to argue that a specimen in the Linnean Herbarium should be regarded as the type to avoid this difficulty, since the earliest specimen here is 271.3 (opinion of Dr. Stearn based on the number 1 on the sheet) and this is also a twig of *Widdringtonia cupressoides.*

This necessitates a new choice of type for the genus *Brunia* L. The generic description here could not have been based on a flowerless specimen, the illustrations do not show sufficient floral detail and in any case the first description in the Genera Plantarum ed. 1 is accompanied by an asterisk indicating that Linnaeus had seen living material and the only alteration in ed. 5 (1754) is from *limbus patens, bracteis subrotundis* to *limbus patens, laminibus subrotundis.* Of the five species placed in *Brunia*, in addition to *Brunia nodiflora*, in the Species Plantarum, *Brunia levisanus* is a *Leucadendron; Brunia ciliata* is not represented by a specimen and the description is so imprecise that it cannot be identified with any species in the Bruniaceae so that all authors have treated it as a *species incognita* except Brongniart, who thought it might be a *Staavia; Brunia uniflora* does not accord with the generic description since it does not have a *perianthium commune subrotundum, imbricatum, multiflorum.* The remaining two species, *Brunia lanuginosa* and *Brunia abrotanoides*, accord with the generic description in all respects except that, though they have a *stylus simplex*, they do not have a *stigma bifidum.* Of these two species *Brunia abrotanoides* can only be typified by an illustration since the specimens in the Linnean Herbarium are later additions, but the type of *Brunia lanuginosa* is in the Clifford Herbarium and was, therefore, definitely examined by Linnaeus before the first description of the genus in the Species Plantarum ed. 1.

Since *Brunia lanuginosa* L. is the basionym of *Berzelia lanuginosa* (L.) Brongn., the type species of the genus *Berzelia* Brongn., a proposal for the conservation of the generic name *Berzelia* has been put forward to obviate the highly confusing change in nomenclature that will otherwise be necessary. In the interim it is suggested that conventional nomenclature be adhered to in *Berzelia.* The family Bruniaceae is already listed in the list of *nomina familiarum conservanda* and can remain since when conserved, the family name may be based upon a generic name now treated as a synonym. The problem of the genus incorrectly known as *Brunia* will be treated in a later article.

The problem of *Widdringtonia* still remains. Marsh in the Flora of Southern Africa **1,** concluded that *Widdringtonia cupressoides* should be used for this

species on the basis of the description of *Thuja cupressoides* L. in the Mantissa plantarum (1767), though no type specimen could be found. She rejected *W. juniperoides* L. in Species plantarum ed. 2 (1763) since the inadequate description was based on seedlings said to have come from 'Cap. b. spei' but with no specimen available in the Linnean Herbarium.

The description of *Brunia nodiflora* in the Species plantarum ed. 1 (1753) antedates both of these descriptions and the type specimen is *Brunia* 1 in the Clifford Herbarium. A new combination is, therefore, necessary, as follows:

Widdringtonia nodiflora (L.) Powrie comb. nov.

Basionym: *Brunia nodiflora* Linnaeus, Species plantarum ed. 1: 199 (1753).

Type specimen: *Brunia* 1 in the Clifford Herbarium (BM).

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THE EVERGREEN FORESTS OF MALAWI by J. D. Chapman and F. White, with pp. 190, 9 text figures and 60 black and white photographs. Commonwealth Forestry Institute, University of Oxford, 1970. £2/50.

This is one of those rare publications on segments of African vegetation which merit the attention of serious field botanists.

Both authors know what they are talking about. Where they do not, they generally admit their ignorance and make sensible suggestions for enlightenment. Consequently it is a *usable* and rewarding text for the ecologist and plant geographer. The data contained therein have a validity beyond the influent region of Malawi and her neighbours. Only here and there in Part I is there a degree of pontification.

The junior author admits that his acquaintance with Malawi is slight and presumably this also applies to the territories further south. This lack of field experience would certainly account for some anomalies recorded in the phytogeographical analysis and is further testimony — if any were needed — of the inadequacy of herbarium records in analysing the spatial relationships of taxa. Probably it is best, as White suggests, to concentrate on limited areas and plant formations and leave the major floral regions for future investigation when more data are available.

This is, in essence, what the authors have very successfully done and we can all use most of the information with assurance. The Malawi forests are reasonably well-known and are of considerable phytogeographical and ecological interest, situated as they are more or less midway along the great migration routes of Africa. As a result of the indefatigable field work of Mr. Chapman, a high proportion of key taxa has been documented.

Part I includes the main environmental features of the territory. This is followed by chapters on phytogeographical relationships of components of the forests and the classification of forest types. This latter will probably require drastic modification. Importance values of the species are based upon ecological, plant geographical and taxonomic parameters. In Part 2 the individual forests, more than ninety-five per cent of the total for Malawi, are described in detail with the assistance of soil analyses and profile diagrams. There are admirable and very apt photographs and a companionable bibliography. Presumably detailed species lists will appear in a planned volume on "The Forest Trees and Shrubs of Malawi" which we hope will not be long delayed.

There are not more typographical errors than one has come to associate with the printing industry in Britain. There has obviously been some slack proof-reading and the authors still seem in doubt as to current concepts concerning certain taxa. The binding is a bit flimsy which considering the use it should get in the field, is merely spoiling the ship for a ha'porth of tar.

None of these blemishes or the controversial views and occasional errors of fact detract from the overall value of the work to the trained observer.

I wish we had many more such dealing with other plant formations. Detailed analyses of limited areas will eventually lead to a comprehensive understanding of the origin and history of whole floras and the scientific management of the vegetal cover of Africa. "Evergreen Forests of Malawi" could well serve as a model for those who desire to contribute to these noble objectives.

O. KERFOOT

EXCELSA No. 1, Journal of the Aloe, Cactus and Succulent Society of Rhodesia.

Interest in the study and cultivation of succulent plants is world wide and undoubtedly greater today than ever before. The discovery of the Americas and the explorations of the Cape introduced the wonderfully rich succulent floras to Europe where they intrigued the botanist and gardener alike. Today, there are flourishing succulent plant societies in many countries of the world, issuing their own periodicals, some of high quality and of standards acceptable to professional botanists since many new species have been described therein, often with good and essential illustrations.

Though technically speaking all the botanical subjects in the various periodicals are classified as succulents—where to draw the line between a succulent plant and a non-succulent plant being frequently debated—it appears to have been widely acceptable to use the term Cactus and Succulent in their titles from the earliest days. This is perhaps due to the fact that

these new plant introductions to Europe were, for some time, preponderantly the cacti from the New World.

Perhaps owing to the enormous interest in the genus Aloe today the above publication includes Aloe in the Society's title. Some will consider this an ambiguity.

This comparatively new Society—it was founded in 1969—publishes a quarterly news-letter to its members. It has now produced its first issue of EXCELSA which sets an unusually high standard amongst succulent journals in that it contains no less than 46 colour photographs of superlative quality. This was made possible by the generosity of a number of Rhodesian business houses, for without such public spiritedness reproductions in colour are beyond the finances of any amateur society. Forty of these are from photographs by Mr. D. C. H. Plowes, 31 of which are of the Rhodesian Stapelieae, a group of succulents which has been one of his chief interests for many years. These photographs are accompanied by his account of all the known Rhodesian species in this group.

An account of the vast amount of work done in monographing the genus Aloe by the late Dr. G. W. Reynolds is contributed by Mr. M. J. Kimberley, Mr. E. J. Bullock has compiled a useful check-list of the Aloes of Rhodesia and the reprint of "The Great Tree Aloe of Damara Land" by Thomas Baines, first published in 1866, is of special interest. A "Provision List of Rhodesian Succulents" compiled by Mr. R. B. Drummond will be of considerable practical use.

Professor D. T. Cole contributes notes on "The Growing of Lithops from Seed" and 7 splendid photographs to illustrate them. Although no species of Lithops is known to occur wild in Rhodesia this South African genus is enormously popular and, happily, can be grown fairly readily from seeds.

From the point of view of plant conservation Mr. Kimberley's account of the existing Legislation in Rhodesia is of special interest for there are many people who feel that succulent societies encourage the members to collect wild specimens, thus defeating the objects of the Conservationists. The reviewer has more than once heard references to "succulent cemeteries" —collections falling into neglect and disuse upon the demise of the owners, that plant collecting is a kind of "one-way traffic" and that plants "are never taken back to the veld". The most serious aspect in this regard is the exportation of our rare species by commercial institutions.

It is sincerely hoped that future issues of EXCELSA maintain the same high standard established by its first volume. Further information may be obtained from The Hon. Secretary, P.O. Box 8514, Salisbury, Rhodesia.

H. Hall

PROTEACEAE by C. Venkata Rao, with pp. 208, 75 figures (each with several illustrations) and 9 plates. Botanical Monograph No. 6. New Delhi: Council of Scientific and Industrial Research. 1971. Sh. 68/-.

This publication of the late professor Venkata Rao satisfies a very urgent need for a comprehensive treatise on the Proteaceae, a family which is geographically and morphologically of very great interest. The last comprehensive survey of the family was that of A. Engler in 1889.

The seven chapters of the book are devoted to the geographical distribution, general morphology (organology), anatomy, embryology and seed anatomy (two chapters), cytotaxonomy and classification, and origin, spread, evolution and phylogeny of the family.

The facts are clearly stated and well presented and the conclusions are well substantiated. The book makes very good reading and can readily be prescribed as a textbook for pre-graduate or graduate students.

The author studied representatives of the family from over its whole area—Australia, Africa, America and Asia—and gives a very good picture of the great variation of characters in the family. At least in respect of the embryology, seed anatomy and "style-end" the variation is even greater than expounded by him. The pollen-presenter is not mentioned.

A number of small errors and misrepresentations occur. Several of these can be easily recognised as careless mistakes and are as such not detrimental to the scientific value of the book.

The publication is an important contribution to botany in general, but it will be especially appreciated in Australia and Southern Africa where the family is concentrated and where it is a prominent component of the flora and vegetation.

P. G. Jordaan

KARL BAUR: "DER BOTANISCHE REISEVEREIN ESSLINGEN" in: Jahrbuch fuer Geschichte der oberdeutschen Reichsstaedte. pp. 228-266. Esslinger Studien Bd 16.1970.

The author deals with a brief introduction on the history of the natural sciences in the "Freie Reichsstaedte", particularly on people connected with Esslingen. Some favourable comments on them by Bauhin and Rauwolf are listed. Then follows the history of the founding of the "Botanischer Reiseverein" (Botanical Travel Association). The original press release of the proposed formation of the Association is reprinted. Many accounts of the activities of the Association follow. The very involved participation of the two initiators, Steudt and Hochstetter is dealt with in particular. A great number of footnotes relate to publications in "Flora" and other periodicals of the time, providing a treasure trove for the historically inclined botanist. At its peak the Association's membership included more than 100 individuals and institutions, and among them were such famous botanists as De Candolle and Hooker. These widespread connections ensured that plants collected elsewhere in the world would be described and identified by the best specialists in their fields. Many plants brought to Europe through the activity of the Asscociation are still housed in various famous herbaria. It is quite amusing to read about "dividents" of plants from the Cape which could be obtained by the "shareholders".

The third chapter deals with the various travellers and their fates. Of special interest is, of course, the article on Ecklon and Zeyher and their travels together or in collaboration with Ludwig Beil. Here again a number of footnotes relate to various publications on their collections. One of these publications—the relatively unknown first part of Ecklon's "Topographisches Verzeichnis der Pflanzensammlungen"—was never followed by a second part. Other travellers mentioned are, amongst others, Bertero, Endress, Fleischer, Hohenacker, Huebner, Kotschy, Schimper and Welwitsch. A number of herbaria, where plants of the various collecters are housed, are also named.

Among these short biographies, the story of Wilhelm Schimper's adventurous life in Abyssinia makes particularly interesting reading.

The last chapter deals with a number of other 19th century scientists from Esslingen.

By reading Karl Baur's article one learns a good deal about the closely knit relationships between a formidable number of 19th century scientists, and thus one can understand and appreciate their approach to the problems of the sciences in the light of their time. The actual value of this article lies in the great number of biographical notes and references to many a paper published in periodicals which are no longer in existence. By going into this secondary literature, one might perhaps come across some hitherto overlooked information.

Attention should be drawn to two more articles on the activities of E. F. Hochstetter by Anezka Hrabetova-Uhrova and Maria Habacher which also appear in the book.

W. WISURA

STREPTOCARPUS: AN AFRICAN PLANT STUDY by O. M. Hilliard and B. L. Burtt with pp. xv + 410, Pietermaritzburg; University of Natal Press, 1971. R13.

Glancing back to 1904 when C. B. Clarke published an account of *Streptocarpus* in the *Flora Capensis*, we find that 22 species were recognized for the South African region. Two years later, the 23 *Streptocarpus* species, then known to occur in Tropical Africa, were dealt with in the *Flora of Tropical Africa*, again by C. B. Clarke but assisted by J. G. Baker. Clarke and Baker considered the genus to consist of about 50 species at that stage.

Just how greatly our knowledge has increased since then can be seen from the fact that 132 species (including 4 Asiatic species), are enumerated in *Streptocarpus: An African Plant Study*. Needless to say, Dr. O. M. Hilliard and Mr. B. L. Burtt have been chiefly responsible for this considerable information expansion. At the outset, one must point out that this fine publication is no stodgy taxonomic revision. On the contrary, the great merit of this book is that it contains something for everyone; one third of its pages being devoted to matters of general botanical interest and the remainder to taxonomic aspects. There are chapters dealing with morphology, the flowers, fruits and seeds, growth patterns, phytogeography, evolutionary speculations, the use of *Streptocarpus* in genetics and physiology and, perhaps most fascinating of all, the bizarre vegetative morphology of certain species. Horticulturists will also find much to interest them for hybridization is fully discussed, as is the horticultural history of the genus.

The taxonomic treatment follows the conventional pattern with full synonymy, citation of the types, distribution data, flowering times and many other relevant comments. No herbarium specimens (other than types) are cited which is a great pity, but on reflection one realises that even 5 citations per species would have increased the bulk of the book beyond reasonable limits. The authors have however, been very generous with their keys. Not only is there an artificial key to the whole genus, but there are also 7 separate geographical keys. This is a most praiseworthy idea and there can be no doubt that these regional keys will be a boon to all who have to identify a *Streptocarpus*. Difficulties encounted in delimiting taxa have not for one moment been glossed over. Here, very courageously, the authors have frequently adopted the aggregate concept in dealing with complex groups pointing out possible deficiencies that might be investigated in the future.

Throughout the text, beautifully clear line drawings are provided showing the corolla (natural size) in lateral and frontal view, each drawing conveying the corolla morphology more eloquently than several lines of prose could ever do. 56 individual colour photographs show very adequately the considerable range of colour in the genus and also give good impressions of the habitats although a few of these plates do lack clarity. There are also distribution maps showing the range of each species. To conclude the text, there is a list of chromosome numbers and voucher specimens as well as a short but useful glossary of botanical terms as applied to *Streptocarpus* in particular.

This book represents the culmination of many years of hard work by Dr. Hilliard and Mr. Burtt; a co-operative effort that has been achieved despite the fact that the authors places of work are 6 000 miles apart! As a model of an African plant study, this beautifully produced publication has set a high standard that many botanists in Southern Africa will wish to emulate.

J. P. ROURKE

INDEX OF PLANT NAMES

Note: Plant names appearing in tables or lists are not included in this index. Page references to new taxa are printed in bold type. An asterisk indicates an illustration.